



Intelligent Energy Choices for Kentucky's Future

Kentucky's 7-Point Strategy for Energy Independence



GOVERNOR STEVEN L. BESHEAR

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Foreword

“Kentucky can be a national leader in energy technology and production. We can help the country move toward greater energy self-reliance. I intend to put us on such a path.”

Governor Steven L. Beshear, March 6, 2008

This challenge to all Kentuckians serves as the launching pad to deliver a progressive, integrated energy plan for the commonwealth.

As the third largest producer of coal in the United States, Kentucky’s challenge, our challenge, for the 21st century is to pragmatically adopt inherently cleaner, newer energy sources as well as innovative uses of traditional energy sources. Kentucky can be – and in fact must be – a leader in this energy revolution. We are not alone in this effort.

This bold document, *Intelligent Energy Choices for Kentucky’s Future*, is the beginning of an evolutionary plan for our state. It is an energy plan that will improve the quality of life for all Kentuckians by simultaneously creating efficient, sustainable energy solutions and strategies; by protecting the environment; and by creating a base for strong economic growth.


Kentucky’s plan incorporates recommendations to improve energy efficiency for Kentucky’s homes, businesses and transportation fleet. It provides a framework from which we can begin to increase our use of renewable energy sources. It discusses the potential for biofuels as well as coal-to-liquids and coal-to-gas technologies. It recommends the initiation of an aggressive carbon capture/sequestration program for coal-generated electricity. It provides a discussion of how Kentucky could initiate and grow safe and reliable nuclear power for electricity generation in Kentucky.

By refining and adopting this energy plan, the Commonwealth of Kentucky hopes to establish leadership in the United States for innovating and creating efficient, sound and environmentally compatible energy solutions and strategies. Every journey has a destination. This plan is a road map for a journey to energy independence. We will know we have reached our destination when we have accomplished six important things:

- Conserve and use energy more efficiently.
- Achieve energy independence for transportation fuels.
- Use coal more cleanly and efficiently.
- Diversify electricity generation to optimize use of renewable and alternative fuels, in addition to coal, Kentucky’s leading fossil fuel, and nuclear.
- Mitigate carbon dioxide emissions, reducing our carbon footprint.
- Establish Kentucky state government as a leader in green practices.

As part of these proposals, we must have broad discussions of our options, alternatives, benefits and priorities for our state. It is paramount that we realize the consequences of doing nothing – consequences for our generation and the generations of Kentuckians to come.

We must contend with the reality that our state’s energy policy will be increasingly shaped by decisions at the national level. These national decisions will undoubtedly accelerate energy development and independence within the guidelines of environmental protection as a national priority. It is imperative that we have policies and programs in place that allow Kentuckians to protect and utilize our energy resources in an environmentally sound manner and help us to achieve energy independence. The tenets and spirit of this vital strategic plan will help us do that.



Steven L. Beshear, Governor



Leonard K. Peters, Secretary
Energy and Environment Cabinet

Executive Summary

KENTUCKY'S CHALLENGE for the 21st century is to develop clean, reliable, affordable energy sources that help us improve our energy security, reduce our carbon dioxide emissions, and provide economic prosperity. Kentucky can be – and in fact must be – a leader in this energy revolution.

Energy independence is a top challenge to the state and the nation in the 21st century, a challenge that has been made at once more urgent and more complex by the equally pressing issue of global climate change. For a major coal-producing state that also relies on coal to generate more than 90 percent of its electricity, addressing these two issues – energy security and climate change – is especially problematic.

We have to contend with the reality that, going forward, our state's energy policy will be increasingly shaped by decisions at the national level, decisions which in turn are being driven by significant global issues and events. As a state, it is imperative that we have policies and programs in place that allow us to shape our own energy future by making sure we utilize our energy resources in an environmentally sound manner. This strategic action plan, *Intelligent Energy Choices for Kentucky's Future*, is intended to place Kentucky on such a path.

Intelligent Energy Choices is an action plan for our state that is intended, first and foremost, to improve the quality and security of life for all Kentuckians by creating efficient, sustainable energy solutions and strategies; by protecting the environment; and by creating a base for strong economic growth over the long term. We must make changes in order to accomplish these objectives. In addition to identifying new initiatives, the plan provides an important framework around existing policies and activities so that we can aggressively increase our use of renewable energy sources; improve the energy efficiency of our homes and buildings; develop cleaner methods to utilize our fossil energy resources; diversify our electricity and transportation energy portfolios; and more fully integrate our agricultural and energy economies.

Intelligent Energy Choices is designed to be a 'living' document that serves as a means for the state – the general public, public officials, educators, business and industry at all levels, and others – to craft a consensus for a comprehensive, holistic energy plan for the betterment of all. It is an evolutionary plan that is not intended to be exhaustive at the outset. We cannot address every single issue in this relatively comprehensive document; thus, there will be additional issues that need action on a case-by-case basis. We have made a concerted effort to include all the highest priority actions that will serve as an underpinning, a foundation, for great progress and for future actions through 2025.

Kentucky Must Act Now

Kentucky's energy use is projected to grow by slightly more than 40 percent between now and 2025 under a Business-As-Usual scenario. This energy growth encompasses all sectors, including electricity generation, natural gas use, and transportation fuels. For example, between now and 2025, according to estimates from the Kentucky Public Service Commission, Kentucky will need an additional 7,000 megawatts of electricity generation (PSC, 2005).

Intelligent Energy Choices is designed to lead to a much more diversified energy portfolio for the commonwealth and provide economic, environmental and energy security benefits. In the future, primarily relying on one source of power for electricity generation will not be prudent in the face of imminent climate change legislation at the federal level. While we anticipate retrofits of existing power

plants for carbon dioxide capture, our electricity generation must be diversified to include renewables and other sources, such as nuclear power.

This plan allows us to develop flexibility in our energy portfolio so that we can take timely advantage of technological advances in such areas as cellulosic biofuels, solar and wind, and carbon management. A diverse portfolio gives us the flexibility to effectively utilize lower carbon-emitting technologies and fundamentally more environmentally benign energy solutions.

Just as we will experience growth in our demand for energy, our greenhouse gas (GHG) emissions will escalate if we continue down the same path. With such a high reliance on fossil fuels, Kentucky's projected GHG emissions could be more than 40 percent higher than they are today if we do not take action. With implementation of the seven proposed strategies, however, our GHG emissions will be more than 50 percent lower in 2025 than they would otherwise be. More significantly, GHG emissions in Kentucky will actually be 20 percent lower in 2025 than were our 1990 emissions (Figure ES-1).

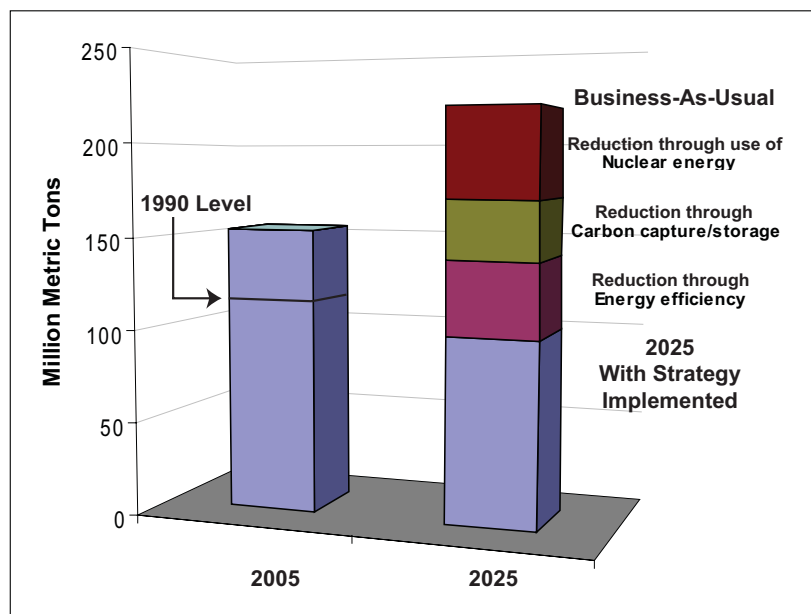


Figure ES-1: Reductions In Carbon Dioxide Emissions

Relying on coal-fired power generation in the state will not be sufficient to support Kentucky's coal industry if other states cease purchase of Kentucky coal. By diversifying the coal industry's product line into transportation fuels and synthetic natural gas, we support our efforts to become less vulnerable to imports and ensure a continued market for Kentucky coal, sustaining the 17,000 plus jobs in the coal industry, as well as the industry's other economic effects.

Kentucky's Plan Outlines Seven Strategies

The plan proposes a Renewable and Efficiency Portfolio Standard (REPS) whereby 25 percent of Kentucky's energy needs in 2025 will be met by reductions through energy efficiency and conservation and through use of renewable resources. *Strategies 1, 2, and 3* are designed to help the commonwealth achieve the REPS. Leading with energy efficiency, conservation, and renewable energy allows us to implement actions to reduce energy use and carbon dioxide emissions in a timely and cost-effective manner. However, even with an aggressive REPS, Kentucky will still need to look at our traditional energy source – coal, with an expanded cleaner product line – and other options such as nuclear.

Our growing reliance on imported oil presents economic and security threats that are untenable. Therefore, the plan also proposes an Alternative Transportation Fuel Standard (ATFS) to help us

transition away from dependence on foreign petroleum. Kentucky can displace 60 percent of its reliance on foreign petroleum by utilizing fuels such as those derived from biomass and coal, plug-in hybrid vehicles, and compressed natural gas (CNG), and we can do this by building upon our existing infrastructure. Elements of the ATFS are captured in *Strategies 1* (plug-in hybrids), *3* (biofuels) and *4* (coal-to-liquids and natural gas).

Equally important as weaning the state from imports of foreign oil is reducing our dependence on imported natural gas. *Strategy 5* establishes an action plan directed toward increased natural gas production in the commonwealth and production of synthetic natural gas from Kentucky's coal resources.

To achieve our greenhouse gas reduction goals, deployment of carbon dioxide capture and storage technologies on a large scale is crucial. The action plan in *Strategy 6* will help Kentucky initiate aggressive carbon capture and storage projects, with a goal that by 2025, 50 percent of Kentucky's coal-based energy facilities will be equipped with carbon management technologies.

A final key component to reducing Kentucky's carbon dioxide emissions is deploying non-carbon dioxide emitting technologies to meet our baseload electricity generation needs in the future. One option that must be considered is nuclear power. *Strategy 7* provides an important discussion of the environmental, security and economic issues surrounding nuclear power.

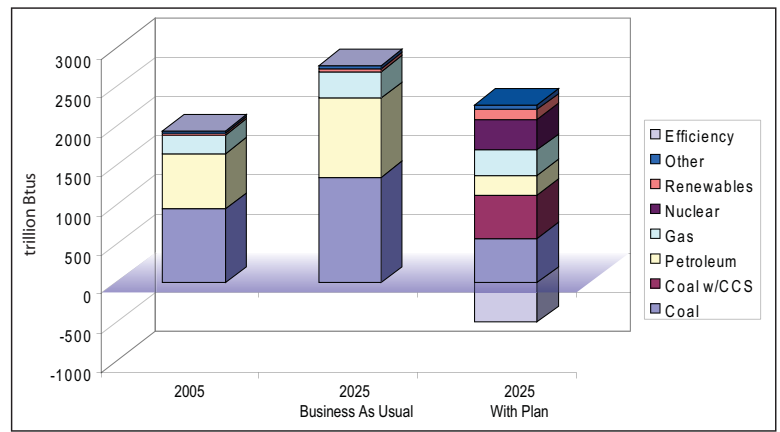


Figure ES-2: Kentucky's Total Energy Use

Figure ES-2 summarizes Kentucky's current energy demand and what can be accomplished with this plan. The bar charts show the current energy mix, what it will look like in a Business-As-Usual scenario, and how this plan will provide a much more flexible and effective energy portfolio.

Following is an overview of the goals and actions of each of the seven strategies. It is important to note that *Strategies 1, 2 and 3*, as part of the Renewable and Efficiency Portfolio Standard, form a three-part vision to provide 25 percent of Kentucky's energy needs by 2025 through energy efficiency, renewable energy and biofuels. Additionally, *Strategies 1, 3, and 4*, as part of an Alternative Transportation Fuel Standard, are part of a goal to reduce Kentucky's dependence on imported oil by 60 percent by 2025.

Strategy 1: Improve the Energy Efficiency of Kentucky's Homes, Buildings, Industries, and Transportation Fleet

Kentucky has been a high user of energy largely because of our historically low electricity rates. We have had little incentive to conserve, and thus we are over-users. This must change. Kentucky can achieve its greatest and most cost-effective reduction in GHG emissions through energy

efficiency in all sectors: residential, commercial, industrial and transportation. We can forestall construction of some additional generation facilities through energy efficiency. Therefore, our leading strategy, and our utmost advantage in achieving the overall objectives of this plan, is greater energy efficiency.

Goal: Energy efficiency will offset at least 18 percent of Kentucky's projected 2025 energy demand.

Both nationally and worldwide, we are experiencing dramatic increases in costs for our traditional nonrenewable sources of energy – coal, natural gas and petroleum. It is likely that the prices for these global commodities will continue to increase, and therefore consumers' energy bills will continue to rise. Most would agree that the era of cheap energy is over. The choice we face is to take no action and see large price increases with limited economic security, or to take prudent actions now and realize a better chance for smaller price increases as well as increased economic security. In the near term, energy efficiency and conservation represent the fastest, cleanest, most cost-effective, and most secure methods we have to reduce our growing demand for energy and to help us address issues surrounding global climate change.

Actions to Achieve the Goal

- An Energy Efficiency Resource Standard (EERS) will be established to support the energy efficiency portion of the REPS with a goal of reducing energy consumption by at least 16 percent below projected (with no changes) 2025 energy consumption. To achieve the EERS a combination of both utility-sponsored and non-utility-sponsored energy efficiency programs will be developed and implemented.
- Transportation energy efficiency programs will contribute another two percent reduction representing energy savings corresponding to approximately 500 million gallons of motor fuel annually. Elements of this component of *Strategy 1* support the objectives of the ATFS.
- Kentucky will initiate strong education, outreach and marketing programs that will support all energy efficiency activities.
- An energy efficiency program will also be established for state government that has aggressive internal energy savings targets. This program is important as it establishes a leadership role for state government, and creates many new, well informed energy efficiency advocates for Kentucky.

Strategy 2: Increase Kentucky's Use of Renewable Energy

Kentucky currently relies on renewable resources for less than three percent of its electricity generation. The commonwealth has the 5th largest hydro power production east of the Mississippi, and several of our utilities are utilizing landfill gas for electricity generation. The potential to increase both of these resources, especially through landfill gas, is encouraging. However, with today's technologies, our ability to use some resources such as wind and solar for baseload generation is limited in Kentucky. As technologies advance in the next few decades, this scenario can change. In the meantime, especially as part of the utility resource planning process, Kentucky

should aggressively pursue its options for renewable generation in order to achieve greenhouse gas reductions and diversify our energy portfolio.

Goal: By 2025, Kentucky's renewable energy generation will triple to provide the equivalent of 1,000 megawatts of clean energy while continuing to produce safe, abundant, and affordable food, feed and fiber.

Kentucky does have supplies of non-fossil natural resources that can help contribute to a clean and secure energy future, natural resources such as wind, solar, hydropower, biomass and methane. Energy from renewable resources benefits the environment while creating economic opportunities – the “green collar” jobs for businesses, industries and rural communities. To achieve this goal, the commonwealth must aggressively invest in the development of its renewable energy resources.

Actions to Achieve the Goal

- State government will lead by example by requiring new or substantially renovated public buildings to use renewable energy as a percentage of total energy consumption. The requirements will escalate over time to reflect the state's renewable energy and energy efficiency goals. The High Performance Building Committee established in House Bill 2 (2008 regular session) will establish renewable energy targets for 2012, 2018, and 2025 for new or substantially renovated buildings.
- Kentucky's Energy and Environment Cabinet (EEC) will recommend policies and incentives necessary to achieve the state's renewable energy goal. The analysis will include implementation plans for the REPS for Kentucky's electric utilities.
- As Kentucky's forest resources can potentially contribute more than 50 percent of Kentucky's renewable energy potential, the state will review its policies and regulations to encourage the responsible, sustainable use of woody biomass within the guidelines of environmental protection.

Strategy 3: Sustainably Grow Kentucky's Production of Biofuels

Kentucky currently uses only five to 10 percent of its potential biomass resources for the production of biofuels such as ethanol and biodiesel. Kentucky can significantly grow its agricultural and forestry resources in an environmentally and economically sustainable way to provide more biofuels for transportation, particularly as biofuel technologies expand in the next decade. We can thereby strengthen our energy security while growing and diversifying our agricultural and forestry economies, as well as reducing our GHG emissions. Through a concerted effort and collaboration with agricultural producers, researchers at universities, and policy makers, Kentucky can grow its biofuels industry to meet 20 percent of our current transportation fuel needs.

Goal: By 2025, Kentucky will derive from biofuels 12 percent of its motor fuels demand (775 million gallons per year, which represents approximately 20 percent of Kentucky's current transportation fuels demand), while continuing to produce safe, abundant, and affordable food, feed, and fiber.

As part of the ATFS, *Strategy 3* focuses on research and development (R&D) as well as deployment of commercial-scale facilities to address technical or infrastructure challenges, thereby enhancing the potential to grow the biofuels market. Kentucky will begin a statewide initiative to ensure that the needed infrastructure, human resources, research and development support, and policies are in place to enable meaningful and sustainable growth in biofuels. Current studies indicate there could be a nearly 10-fold increase in current bio-based fuels in Kentucky.

Actions to Achieve the Goal

- Kentucky will invest in algae and other non-food crops as a feedstock for biodiesel.
- Kentucky will aggressively seek federal support for and invest in ventures that promote a market for ethanol from non-traditional feedstocks, especially feedstocks that do not negatively affect food prices or availability.
- Kentucky will establish an escalating renewable fuel standard (RFS) for the state vehicle fleet.
- Incentives will be created to encourage production, distribution, and demand for biofuels in Kentucky in an environmentally sustainable manner.

Strategy 4: Develop a Coal-to-Liquids Industry in Kentucky to Replace Petroleum-Based Liquids

Energy independence and economic security are major objectives of this plan for Kentucky and for the United States. Volatile petroleum prices beyond our control promise to rise again as the economy recovers. The United States imports 60 percent of its petroleum, largely from unstable regions in the Middle East and South America. But, Kentucky has abundant coal resources and is the third largest coal producer in the United States. The high emissions of carbon dioxide into the environment must be addressed now, as the United States moves toward federal mandates and penalties for coal-fired power generation. Kentucky can diversify ultimate coal utilization, producing cleaner and more efficient energy for state and domestic use. Coal-to-liquid and coal-to-gas technologies can replace petroleum-based liquids and imported natural gas, respectively.

Goal: Kentucky will develop a coal-to-liquids (CTL) industry that will use 50 million tons of coal per year to produce four billion gallons of liquid fuel per year by 2025.

With its vast coal resources, proven support from elected officials, and dedicated research and development program, Kentucky is uniquely positioned to develop a CTL industry that can serve as an engine for economic growth, while helping to reduce our dependence on foreign oil. The actions in *Strategy 4* further support the implementation of the state's ATFS.

Actions to Achieve the Goal

- Kentucky will sanction two 500 million-gallon per year (approximately 35,000 barrels per day) CTL fuel facilities in both 2013 and 2014, and then two additional 480 million-gallon per year CTL fuel facilities by 2018, and two more by 2025, for a total of eight new CTL facilities.
- To ensure that trained personnel are available to staff increased coal consumption required by the CTL industry, Kentucky's EEC will work with the Community and Technical College System to

identify appropriate training programs. To achieve the required employment levels, increased training capabilities should be available within the next three years.

- Kentucky will evaluate its current coal mining capabilities to ensure that it can achieve the necessary levels of coal production to support both coal-fired electricity generation and the development of a CTL industry in the near-term.

Strategy 5: Implement a Major and Comprehensive Effort to Increase Gas Supplies, Including Coal-to-Gas in Kentucky

Today, about 44 percent of Kentucky's total natural gas requirements are met by in-state production; the remainder is imported. The same threats of volatile prices and unstable sources apply to our increasing dependence on imported natural gas, just as they do on our imported oil. Moreover, being largely dependent on external sources of natural gas, Kentucky's consumers pay added transportation costs for the gas we use. As utilities increase the use of natural gas for electricity generation, in order to comply with imminent GHG mandates, both natural gas and electricity prices will increase. We need to increase our energy independence with natural gas, also. Coal gasification technology is neither new, nor experimental. Virtually all of Kentucky's gas needs can be met if we increase our in-state natural gas production and produce synthetic natural gas derived from coal, both of which help us to achieve our overall objectives of economic security and energy independence. A strong coal-to-gas industry will build upon Kentucky's economic development and increase the number of jobs created by the coal-to-liquids industry.

Goal: Kentucky will produce the equivalent of 100 percent of our annual natural gas requirement by 2025 by augmenting in-state natural gas production with synthetic natural gas (SNG) from coal-to-gas (CTG) processing.

Being significantly dependent on external sources of gas today, consumers in Kentucky pay added transportation costs for most of the natural gas that they use. More important, consumers in Kentucky, as in other states, have become vulnerable to possible supply uncertainties and price increases and spikes as these may occur in the U.S. natural gas system and market. Virtually all of the gas needs of Kentucky can be met by increasing Kentucky's own domestic natural gas production supplemented by synthetic natural gas produced by gasifying coal.

Actions to Achieve the Goal

- Research at the University of Kentucky's Center for Applied Energy Research (CAER) should be expanded to achieve optimal processes for converting coal to gas under various combinations of coals and operating conditions.
- Research at CAER should be enhanced to include the life-cycle carbon reduction potential of gasifying biomass with coal in CTG processes.
- A Public Service Commission (PSC) administrative case should be initiated to ensure that Kentucky Local Distribution Companies and customers are not harmed by direct sales of gas from SNG producers to industrial plants.
- Assessments of new natural gas resources in Kentucky should be expanded and accelerated.

- A comprehensive study of pipeline infrastructure in Kentucky should be initiated to determine needs in relation to expanded production of Kentucky's domestic natural gas and coal-bed methane resources.

Strategy 6: Initiate Aggressive Carbon Capture/Sequestration (CCS) Projects for Coal-Generated Electricity in Kentucky

More than 90 percent of Kentucky's electricity is derived from coal-fired power, and we rank 13th in total carbon dioxide emissions. Carbon capture and sequestration (CCS) is crucial to continued use of coal as an energy resource in Kentucky. Success of CCS will determine our ability to meet our future energy needs. Currently, CCS development emphasizes geologic sequestration. We need more technical options for cost-effective carbon management so that coal can be a cleaner energy resource. Of all the technologies addressed in this plan, CCS has the greatest technological uncertainty, which is why this strategy emphasizes the need for research, demonstration, and deployment. Beyond geologic sequestration, the federal government has provided little leadership in carbon management, but will likely establish CCS as a priority in the new administration. Kentucky must protect its coal industry and initiate its own solutions to managing carbon dioxide emissions as it diversifies its product line.

Goal: By 2025, Kentucky will have evaluated and deployed technologies for carbon management, with use in 50 percent of our coal-based energy applications.

There are unique challenges to be faced in a carbon-constrained world, given Kentucky's reliance on coal-fired power generation. The threats associated with climate change will require Kentucky to make a concerted effort to control emissions of carbon dioxide, one of the greenhouse gases, while at the same time recognizing that coal will continue to be a vital component of our energy mix. We must find ways to reduce carbon dioxide emissions and meet our energy needs for the future.

Actions to Achieve the Goal

- The work of the Carbon Management Research Group (CMRG), a consortium of Kentucky's major power companies, the University of Kentucky's Center for Applied Energy Research (CAER), and the Commonwealth of Kentucky's Energy and Environment Cabinet (EEC) should be supported. The CMRG will carry out a ten-year program of research to develop and demonstrate cost-effective and practical technologies for reducing and managing carbon dioxide emissions in existing coal-fired electric power plants.
- Legal hurdles to successful CCS should be examined with recommended legislative solutions provided to the 2010 General Assembly.
- Necessary staff positions in the Division of Oil and Gas should be funded to support Kentucky's primacy over the underground injection control permitting program.
- The EEC should work closely with university researchers and industry partners to undertake one large-scale carbon mitigation project to utilize algae to capture carbon from flue gases, and then convert the algae to biofuels.

- The Consortium for Carbon Storage, which was established by the Kentucky Geological Survey with a seed grant from the EEC should be supported. The Consortium will determine the potential for sequestration and for enhanced oil and gas recovery and enhanced coal-bed methane recovery using carbon dioxide.

Strategy 7: Examine the Use of Nuclear Power for Electricity Generation in Kentucky

With major increases in efficiency and conservation, aggressively utilizing alternative and bio-based energy sources, and more effective use of cleaner coal technologies, we still will not be able to achieve the projected energy demands in 2025 along with meaningful GHG reductions. Thus, other sources of base-load electricity generation will be necessary. Many of our neighboring states are considering nuclear energy. Nuclear power production has no direct carbon dioxide emissions and is already a significant component of the global energy system. Current technologies for nuclear production are superior to the previous generation of plants, complementing an already safe industry in the United States. Improved reliability and efficiency have allowed the industry to maintain its 20 percent share of the growing U.S. electricity market. While the issue of disposal of spent fuel has not been completely resolved, progress will continue to be made to arrive at a solution that addresses the nation's needs.

Goal: Nuclear power will be an important and growing component of the nation's energy mix, and Kentucky must decide whether nuclear power will become a significant part of meeting the state's energy needs by 2025.

In a carbon constrained world, the interdependencies among energy, the environment and the economy will lead to broad sweeping economic transformations in the 21st century. To find solutions that address climate challenges, use our abundant natural resources to gain energy security, and provide the power needed to drive our economy will require pursuit of a diversified mix of energy options. In weighing the benefits and limitations of potential solutions we must be willing to fully assess and understand the societal, technical, and financial trade-offs involved. Nuclear power is one such option that deserves our full attention, as its technology and safety have significantly improved in the last three decades. It also is likely to become a national priority.

Actions to Achieve the Goal

- Legal hurdles to successful inclusion of nuclear power in Kentucky's energy mix should be examined. Specifically, removal or revision of the legislative ban on new nuclear power plants must be addressed.
- A public engagement plan should be implemented to gather and address stakeholder feedback and concerns and to provide education about nuclear power today.
- Research should be conducted to assess the desirability of co-locating nuclear power plants with advanced coal conversion plants to assess the effects on reducing carbon dioxide emissions, providing ready access to electricity and/or steam, and possibly using waste heat for the coal conversion process.
- Incentives that reduce the risk of capitalizing and financing a new power plant should be considered in developing these programs.

- The EEC should work with the Community and Technical College System to ensure that trained personnel are available to staff the construction and operation of nuclear power plants.
- The state universities should explore now the possibility of adding nuclear engineering, health physics, and radiological science programs to their curricula.

Conclusion

An overarching goal of this action plan has been to identify and address those actions that can be implemented in sufficient time to help citizens and businesses prepare for the inevitable changes that will occur in the national and global energy landscape in the years ahead. The scientific community worldwide and global consortia are concerned that we must act immediately to reduce the impact of greenhouse gases on global warming. Environmental protection includes intelligent use of land as well as nonrenewable and renewable resources. This thoughtful strategy will help Kentucky ensure the viability of two signature industries – our mining and agricultural industries – while addressing the global issue of climate change and, at the same time, allowing new vibrant industries that provide high-paying, quality jobs to flourish.

For Kentucky to be a national energy leader, we must fully integrate the development of our energy resources with our mission to protect the environment. Therefore, these strategies address measures to utilize our coal resources in a cleaner, more efficient manner, and in a way that will help us assure energy security. In fully utilizing our biomass, solar, wind, hydro and other renewable energy resources, we not only strengthen our energy and economic security – by diversifying our electricity and transportation fuels portfolios – but we also help the state reduce its carbon dioxide and other greenhouse gas emissions and other pollutants in a significant way. The seven strategies, when implemented, will restructure our energy portfolio in such a way that we can use energy in its broadest sense as a tool for economic development, which Kentucky desperately needs.

With this action-oriented energy plan, by 2025 Kentucky will accomplish the following:

- Provide 30,000-40,000 new Kentucky jobs as a result of a booming diversified energy sector – at least 12,000 directly in our new energy producing sector (3,500 from coal-to-liquids production; 1,800 producing fuels from biomass; 1,700 at coal-to-gas facilities; 4,400 at nuclear plants; and 1,000 at other “green collar,” or renewable energy, industries), and another 20,000-25,000 jobs as a result of the domino effect – jobs which provide indirect support to the new booming energy industry. The increase assumes sustaining current employment, maintaining annual coal production in Kentucky at current levels, with coal mining employment at 17,000.
- Achieve energy independence for Kentucky from imported oil.
- Produce annually approximately four billion gallons of liquid fuels from coal (utilizing about 50 million tons of coal annually).
- Produce annually 135 billion cubic feet of synthetic gas from coal (utilizing about nine million tons of coal annually) to augment Kentucky's natural gas supply.
- Reduce the net per capita carbon emissions into the atmosphere by 50 percent, while ensuring Kentucky's economic viability by protecting Kentucky's coal industry against negative impacts of federally mandated carbon management legislation. This will be accomplished by the combination of implementing the carbon capture and sequestration possibilities as determined by the research conducted in *Strategy 6*, and building nuclear and renewable generating capacities as

described in *Strategies 2 and 7*. The mix of nuclear power, renewable energy, coal-to-liquids and coal-to-gas production, and reduced coal-fired electricity generation will enable compliance with federal mandates while increasing the use of Kentucky's home-grown and most abundant energy resource, coal.

- Optimize our renewable energy resources, utilizing wind, solar, hydropower, landfill gas, and biomass.
- Maintain current energy per capita use despite major energy growth requirements.

Should we fail in these efforts, by 2025 we will be using over 40 percent more energy; paying 20 to 50 percent more for each unit of energy purchased; still bemoaning our reliance on foreign sources of energy; facing a declining coal industry; and finding ourselves captive to limited economic development opportunities.

If we succeed, we shall have produced greater economic and energy security for all Kentuckians, while creating significant job growth and economic development in a wide diversity of agricultural, energy, high tech and service companies; a cleaner and healthier environment; a reduction in Kentucky's contribution to global warming; greater energy efficiencies and independence; and a more substantial corporate tax base to support higher quality healthcare, education and transportation for all of us throughout the Commonwealth of Kentucky.

Introduction

Kentucky Advances in the 21st Century

Kentucky's, and the nation's, prosperity depends on having a reliable supply of clean, sustainable energy now and far into the future. Addressing energy needs and energy conservation is not new. Many remember the issues we faced in the 1970s when the oil embargo crippled our state and the nation. Those issues are heightened today and affect our economic and energy security. Rising oil and natural gas prices have startled consumers, who are actively seeking solutions.

What differentiates the national mood of the 1970s from today are four key issues, all of which are addressed throughout this strategic document.

- Global warming is a known and must be addressed.
- In a global economy, the United States alone controls neither energy prices, nor supply and demand.
- Kentucky's electricity energy infrastructure requires major rebuilding over the next 20 years.
- National security is directly tied to how energy independent we can become.

As stated in a 2007 report by the World Resources Institute, "It now seems certain that climate change and energy security are two of the greatest challenges the global community faces in the 21st century. Energy policies designed to address one of these challenges alone can have unintended and often negative consequences on the other" (World Resources Institute, 2007).

Climate Change Dictates New Best Practices

Today, few still debate the primary cause of climate change. The debate continues, however, about how to implement effective policies designed to help us reduce the cause of climate change. Climate change is already affecting U.S. water and land resources, agriculture, and biological diversity, necessitating corrective actions and the utilization of new resources.

As a major coal-producing state that relies on coal to generate more than 90 percent of its electricity, addressing these two paramount issues, energy security and climate change, is problematic. Kentucky's long-standing support of an industry that provides more than 17,000 high-wage jobs and that brings in more than \$3 billion from out-of-state sales is increasingly being questioned by some who argue that coal is a 20th century energy source. Thus, while we are blessed with abundant coal resources, we must also contend with the implications of using these resources in a world of likely limitations on the emissions of carbon dioxide, a primary greenhouse gas (GHG). Nationwide, coal provides slightly more than 50 percent of the electricity needs, while coal-fired generation accounts for 81 percent of GHG emissions.

Federal legislation imposing limits on GHG emissions did not make it out of the 110th session of Congress; however, most observers agree that such legislation is a matter of when, not if. America's proposed Climate Security Act of 2007, known as the Lieberman-Warner bill, would have cut GHG emissions by two-thirds by the year 2050, largely by means of a cap-and-trade system. The cap would have covered 87 percent of U.S. GHG emissions from the electric power, transportation, and industrial sectors (including natural gas processors and importers and petroleum processors and refiners). Whatever federal legislation is ultimately enacted, we can anticipate that it will have GHG reduction goals similar to the Lieberman-Warner proposal.

Financial Markets Respond to Climate Risks

With GHG legislation a near certainty in the future, Wall Street banks have announced that GHG emissions will factor into their willingness to loan money for building power plants. In February 2008, three of the world's leading financial institutions announced the formation of The Carbon Principles — guidelines on climate change for advisors and lenders to power companies in the United States. The institutions created the Principles as a result of the risks faced by the power industry as utilities, independent producers, regulators, lenders and investors deal with the uncertainties around regional and national climate change policy. If high carbon dioxide-emitting technologies are selected by power companies, the signatory banks have agreed to factor these risks and potential mitigation strategies into the final financing decision.

Kentucky Acknowledges Climate Change's Impact on Coal-Fired Electricity Generation

Kentucky is the third largest coal-producing state (Wyoming is first and West Virginia second). Kentucky accounts for roughly one-tenth of total U.S. coal production and nearly one-fourth of U.S. coal production east of the Mississippi River. With Kentucky's historic reliance on coal-fired base load generation, the state has enjoyed some of the lowest electricity rates in the country. Our low rates have allowed energy-intensive industries to flourish in the state. Our low rates have also encouraged Kentuckians to become some of the greatest consumers of electricity in the country. Kentucky's per capita consumption of residential electricity is among the highest in the United States (Energy Information Administration, 2006).

Kentucky's electric power industry emitted more than 93 million metric tons of carbon dioxide in 2006, and the state was ranked seventh in the United States in per capita emissions and 13th in overall carbon dioxide emissions (3.8 percent of the U.S. total). In May 2008, a Brookings Institute report identified Lexington as having the highest per capita carbon footprint in the United States, and Louisville as one of the top five emitters. The Brookings report primarily implicated coal-fired electricity generation for the high carbon footprint of these two cities.

According to a 2007 U.S. Energy Information Administration (EIA) report, electric utilities will account for the vast majority of emissions reductions under any Congressional GHG legislation. The EIA reports that power plants will account for between 80 and 90 percent of such reductions by 2030. According to the report, the decline in power-plant emissions would reflect reduced reliance on coal, with usage as much as 62 percent to 89 percent below what would otherwise be the case by 2030.

In May 2008, a Brookings Institute report identified Lexington as having the highest per capita carbon footprint in the United States, and Louisville as one of the top five emitters.

The report also predicts that many existing coal-fired plants will likely be retired because it will not be practical to retrofit the facilities with capture-and-storage technology. At the same time, Kentucky's demand for electricity is projected to increase. The Kentucky Public Service Commission estimates an additional 7,000 megawatts of generating capacity will be needed by 2025, or an overall annual growth rate of 1.7 percent. The average age of Kentucky's electric generating fleet is 35 years, and therefore will lead to major changes in Kentucky's electrical energy portfolio

over the next two decades. The EIA indicates that most power companies will likely increase their use of nuclear power, renewable fuels, and natural gas as a result of these pressures.

Energy Independence Means Energy Security

The United States Imports 60 percent of its Oil and Natural Gas

The United States currently imports approximately 60 percent of its petroleum, more than half of which comes from insecure or unstable regions of the world.

The EIA predicts that our dependence on imports will grow to more than 70 percent by 2025, unless the United States takes aggressive steps to develop domestic energy supplies. In its 2008 Annual Energy Outlook, the EIA also projects that worldwide demand for oil will remain high, despite very high prices for gasoline.

Many energy experts point out the normal demand response to high prices is not occurring at the international level. The demand for gasoline in the United States has relented somewhat since 2007, due to high prices, but

worldwide, demand for oil and energy is strong and growing as countries are developing economically and therefore requiring larger percentages of energy inputs. This is not a short-term trend.

The International Energy Agency (IEA) estimates that global energy demand will increase 55 percent by 2030, with nearly 75 percent of that demand coming from developing countries.

Compounding this challenge, oil and gas in the ground is becoming more costly to extract. Given the crude oil price volatility we have witnessed in the past year and given that most experts expect prices to go up again once the worldwide economy rebounds, the strategies and options of the last few decades can no longer be counted upon to mitigate the economic impacts caused by sustained volatile or high oil prices.

Thus, economic and energy security needs have created an overarching demand for greater energy independence, with a decided shift towards domestically available resources.

The United States currently imports approximately 60 percent of its petroleum, more than half of which comes from insecure or unstable regions of the world.

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Kentucky Plans Multilayered Strategies to Resolve Energy Issues

There is no single solution to our energy challenges. We must focus on strategies that employ all existing and emerging technologies and practices that work for Kentucky, finding new ways to utilize existing resources with the objectives of high efficiency, energy independence and the reduction of our carbon footprint. This document is not intended to be exhaustive. We do not, and cannot, address all possible actions that the commonwealth must take over the next two decades, and there will be additional important issues that require action. We have, however, attempted to address the major overarching and far-reaching actions that are crucial to Kentucky's future.

We must remain open to the timely incorporation of future technologies as they emerge with exhibited capabilities of greater efficiency and environmental friendliness. For example, to combat the risks inherent in our increasing dependence on imported oil and the escalating costs associated with growing worldwide demand for all energy resources, the United States, including Kentucky, has available a potentially large alternative liquid fuels resource base in the forms of coal and biomass to substitute for conventional oil imports. The development of alternative fuels from our domestic resources can move us toward transportation fuel independence, while at the same time creating high-value jobs and reducing trade and budget deficits. Additionally, this strategy provides a long-term market for Kentucky coal.

Kentucky has been responding to its energy challenges in a number of ways. Within the past two years the Kentucky General Assembly enacted House Bill 299, House Bill 1 and House Bill 2. These bills established mechanisms to promote renewable energy projects and energy efficiency technologies within the state as well as development of alternative transportation fuels from our coal and biomass resources. See Appendix A for a detailed list of Kentucky legislation related to energy during the last decade.

In 2007, Kentucky's General Assembly also took an important step in addressing issues of carbon dioxide unique to Kentucky. It directed a collaborative report on carbon management related to existing and new electricity-

“Coal is a low-cost, per BTU, mainstay of both the developed and developing world, and its use is projected to increase. Because of coal’s high carbon content, increasing use will exacerbate the problem of climate change unless coal plants are deployed with very high efficiency and large scale CCS is implemented. CCS is the critical enabling technology because it allows significant reduction in carbon dioxide emissions while allowing coal to meet future energy needs.”

MIT, The Future of Coal

generating units, and provided funding for research on carbon capture and sequestration (CCS) from existing power plants; carbon storage in geologic formations; and enhanced oil and gas recovery through carbon dioxide injection. As a result of this funding, important industry-public sector-university collaborations have developed.

These significant pieces of legislation have established a foundation upon which to build an effective, comprehensive statewide energy strategy and have provided funding for the state to initiate key energy-related projects.

In June 2008, Governor Steve Beshear announced the state's partnership with the newly formed Western Kentucky Carbon Storage Foundation. With four key energy industry leaders – Peabody Energy, ConocoPhillips, E.ON U.S. and TVA – and with the Kentucky Geological Survey, the Foundation will test a western Kentucky site for geological sequestration and help to advance the science and ultimate deployment of long-term carbon storage opportunities in the state.

Moreover, Kentucky's Public Services Commission (PSC) announced in October 2008 that it has encouraged the major investor-owned utilities to invest \$7.8 million into established carbon capture and

sequestration (CCS) research programs. The two research entities are the Carbon Management Research Group (CMRG), which is a partnership of the private sector and the University of Kentucky Center for Applied Energy Research (CAER); and the Kentucky Consortium for Carbon Storage (KCCS), which was created by the Kentucky Geological Survey and the Kentucky Department for Energy Development and Independence. KCCS is conducting the test of underground carbon storage in western Kentucky.

According to the World Resources Institute (WRI), "Interest in CCS has grown in recent years since it would significantly reduce emissions from fossil fuels, which are expected to continue to meet the world's energy needs for decades to come, due to their widespread availability and low cost. Challenging economic, technical, social, and institutional hurdles remain, however, before CCS can contribute significantly to a larger climate solution" (WRI, 2007). Among these challenges are legal and regulatory issues associated with CCS.

Thus, Kentucky's challenge is also a challenge at the national and international level. While we must diversify our energy mix, we must also find ways to utilize our coal resources in a carbon-constrained world.

Clean coal technology and technology to capture and sequester carbon dioxide are crucial to Kentucky's continued use of our coal resources; however, considerable development and demonstration work remains to be completed to ensure economically viable systems can be installed at the scale needed.

Many state and regional initiatives across the country are helping to frame the debate on climate change and determine the policy outcome regarding GHG emissions. In fact, in the United States, most of the actions toward addressing climate change are taking place at the state and regional level.

Kentucky is a participant in many of these regional activities, and has recently joined the Climate Registry, a nonprofit organization governed by a board of directors of state, tribal, and provincial representatives that provides a mechanism to measure GHG emissions across industry sectors and borders.

Clean coal technology and technology to capture and sequester carbon dioxide are crucial to Kentucky's continued use of our coal resources; however, considerable development and demonstration work remains to be completed to ensure economically viable systems can be installed at the scale needed.

"Non-Renewables" Dominate Kentucky's Energy Production and Use Today

World events, climate change, uncertain supplies, and an ever-growing global demand for fossil fuels have converged to place our collective energy future in jeopardy. We can no longer count on a limitless supply of inexpensive fossil fuel to meet our future energy needs. Before discussing the energy plan's seven strategies and how they can guide us in the following decades, an overview of Kentucky's current production and use is provided on the next page.

Today, coal, natural gas, and petroleum account for 97 percent of Kentucky's total energy consumption. (See Figure 1.) The other three percent of the energy consumed in Kentucky comes primarily from hydroelectric and other renewable sources.

Petroleum

Kentucky receives petroleum products by pipeline and river barge. The state's total petroleum consumption is high (133,524 thousand barrels per year in 2005) relative to its population. Until October 2008, diesel prices increased almost 70 percent (\$2.72 to \$4.61 per gallon) in the last year; gasoline prices increased over 31 percent (\$3.08 to \$4.04 per gallon) in the same period. Petroleum prices decreased toward the end of 2008 as a result of decreased worldwide demand due to the economic downturn.

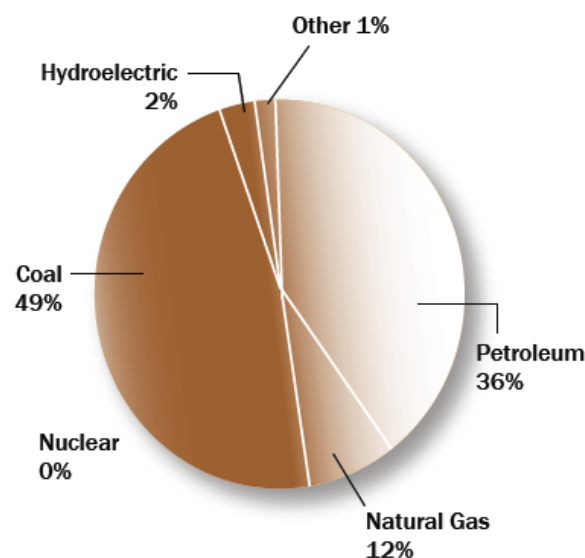
Natural Gas

Kentucky's natural gas production, most of which comes from the Big Sandy field in Eastern Kentucky, typically accounts for less than one percent of total annual U.S. natural gas production. The majority of Kentucky's natural gas demand is supplied by pipelines from the Gulf Coast. Industry is Kentucky's largest natural gas-consuming sector, accounting for about one-half of total natural gas consumption. More than two-fifths of Kentucky households use natural gas for home heating.

Natural gas prices have increased over 13 percent (\$10.71 to \$12.13 per thousand cubic feet) in the last year.

Coal

As noted previously, Kentucky is the third largest coal-producing state. It accounts for roughly one-tenth of all U.S. coal production and nearly one-fourth of U.S. coal production east of the Mississippi River. In addition, almost one-third of all the coal mines in the country are found in Kentucky, more than in any other state. With both surface and underground coal mines, large volumes of coal move in and out of Kentucky by railcar and river barge to more than two dozen states, most of which are on the East Coast and in the Midwest. In Kentucky, about three-fifths



Source: Energy Information Administration.

Figure 1: Kentucky's Energy Consumption by Source-2005

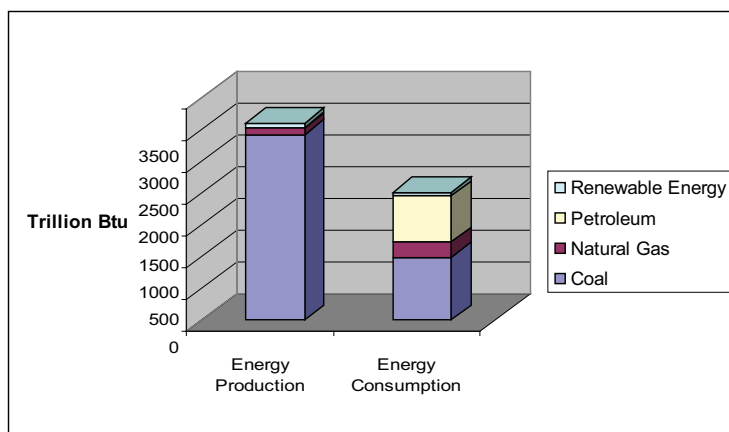


Figure 2: Comparison of Kentucky's Energy Production and Energy Consumption in 2005 by Source (all sectors)

of the coal supply is used for electricity generation, and most of the remainder is used in industrial plants. Kentucky exports nearly two-thirds of its coal mined each year to other states. (See Figure 2.)

Coal-fired power plants typically account for more than 90 percent of the electricity produced within Kentucky, making it one of the most coal-dependent states in the nation.

The price of Central Appalachia coal has doubled (\$57.70 to \$117.60 per ton) in the last year. Electricity prices, although increasing, have not yet begun to reflect this price run-up. If coal prices remain at these high levels, electricity prices will also spike.

Several hydroelectric power plants account for most of the state's remaining electricity generation. Kentucky is currently the fifth largest hydroelectric power producing state east of the Mississippi River.

Coal-fired power plants typically account for more than 90 percent of the electricity produced within Kentucky, making it one of the most coal-dependent states in the nation.

Kentucky Envisions the Future

The commonwealth already enjoys many comparative advantages in energy production, including a strong natural resource base, a highly skilled workforce with a strong work ethic, a highly qualified community of educators and researchers, and the commitment of its state government and legislature to achieve energy independence and reduce its carbon footprint. Building on these advantages, while encouraging innovation and ingenuity, will help Kentucky move forward to a secure energy future.

Responding effectively to the world's new energy realities is one of our most urgent and important challenges. We must identify and pursue aggressive, yet achievable, solutions to meet our energy needs. The following seven strategies presented in this action plan will make Kentucky a leader in the nation's efforts to attain energy independence and will provide environmental and economic benefits to the citizens of the state.

1. Improve the energy efficiency of Kentucky's homes, buildings, industries and transportation fleet.
2. Increase Kentucky's use of renewable energy.
3. Sustainably grow Kentucky's production of biofuels.
4. Develop a Coal-to-Liquids (CTL) industry in Kentucky to replace petroleum-based liquids.
5. Implement a major and comprehensive effort to increase gas supplies, including coal-to-gas in Kentucky.
6. Initiate aggressive carbon capture/sequestration projects for coal-generated electricity in Kentucky.
7. Examine the use of nuclear power for electricity generation in Kentucky.

We shall become an energy producing state for our nation while at the same time achieving efficiency in our personal energy use. This will lead us to a position of leadership in the United States and to strong economic development, as we mitigate GHG emissions, and provide revolutionary positive changes in Kentucky by 2025.

Kentucky Must Act Now

Kentucky's energy use is projected to grow by slightly more than 40 percent between now and 2025 under a Business-As-Usual scenario. This energy growth encompasses all sectors, including electricity generation, natural gas use, and transportation fuels. Reliable estimates show an annual growth in electricity generation alone of close to two percent. As noted, between now and 2025, according to estimates from the Kentucky Public Service Commission, Kentucky will need an additional 7,000 megawatts of electricity generation. The anticipated additional generation does not even account for the retirement of existing coal-fired plants, whose average age in Kentucky is already more than 35 years.

This plan, *Intelligent Energy Choices for Kentucky's Future*, will substantially reduce energy demand such that per capita energy use in Kentucky will remain at current levels.

Implementing these strategies will also lead to a much more diversified energy portfolio for the commonwealth, while we expand economic development opportunities in all energy sectors. Figure 3a shows the current energy utilization, what it will look like in the BAU scenario, and how this plan will provide a much more flexible and effective energy portfolio. Diversifying Kentucky's energy portfolio provides enormous economic, environmental and energy security benefits, and will be key to the state's prosperity in the future. If we rely on the same model we have today, we will be increasingly vulnerable to these threats and our citizens, businesses, and industries will all be negatively affected.

For example, today, we rely on coal for more than 90 percent of our electricity. Our industrial sector has flourished as a result of low-priced coal-fired generation. In the future, primarily relying on one source of power for electricity

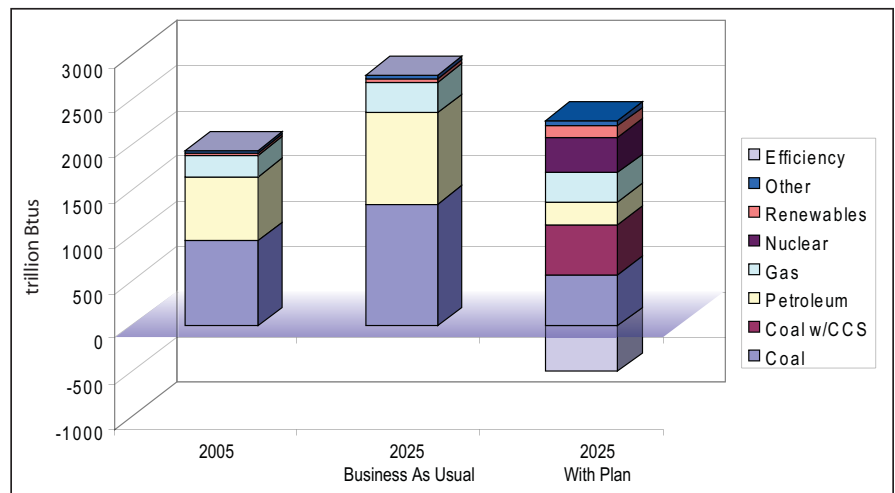


Figure 3a: Kentucky's Total Energy Use

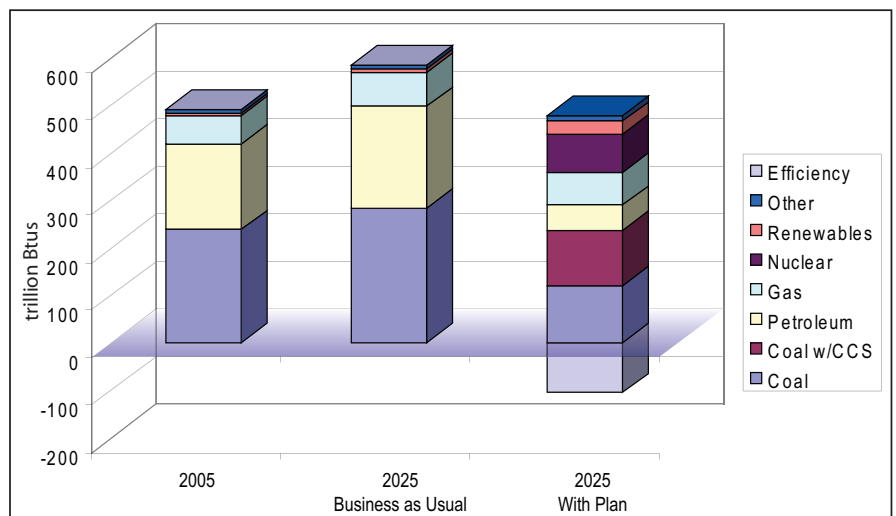


Figure 3b: Kentucky's Per Capita Energy Use

generation will not be prudent in the face of imminent climate change legislation at the federal level. While we anticipate retrofits of existing power plants for carbon dioxide capture, we must diversify our electricity generation to include renewables and other sources such as nuclear power.

At the same time, relying on coal-fired power generation in the state will not be sufficient to support Kentucky's coal industry. If other states cease purchase of Kentucky coal, our coal industry and the resulting severance taxes will be diminished considerably. By moving some of our coal production into transportation fuels and synthetic natural gas, we support our efforts to become less vulnerable to imports and ensure a continued market for Kentucky coal, sustaining the 17,000 plus jobs in the coal industry, as well as the industry's other effects.

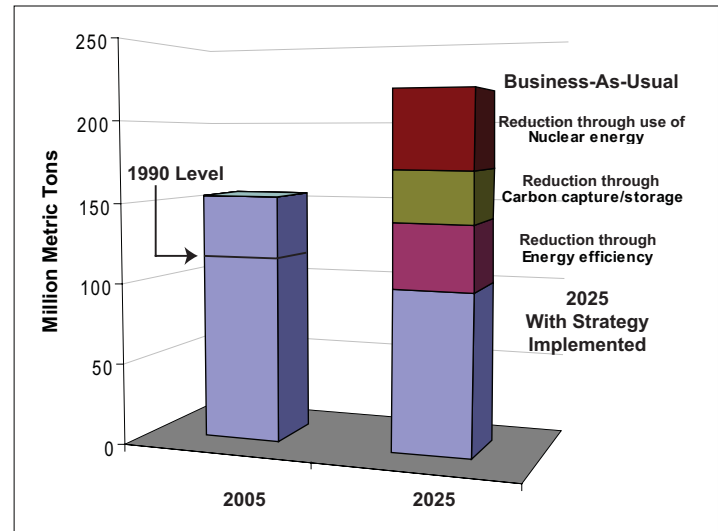


Figure 4: Reductions In Carbon Dioxide Emissions

We cannot predict with certainty the technological advances that will occur over the next two decades, but we can develop flexibility in our energy portfolio that enables us to take timely advantage of those advances. For example, if cellulosic biofuels develop rapidly, we will have in place the basic industry to readily adapt to these technological advances. If much more efficient and economical solar or wind technologies are developed, we will be able to exploit those without delay. If nuclear power takes hold more rapidly at the national level, which indications are it will, our utilities could already be moving in that direction. A diverse portfolio gives us the flexibility to effectively utilize lower carbon-emitting technologies and fundamentally much more environmentally benign energy solutions.

Just as we will experience growth in our demand for energy, our GHG emissions will continue to escalate under a Business-As-Usual scenario. With such a high reliance on fossil fuels, our projected GHG emissions will be more than 40 percent higher than they are today if we do not take action (See Figure 4). With implementation of these proposed strategies, however, our GHG emissions could be more than 50 percent lower in 2025 than they would otherwise be. More significantly, if we implement the strategies presented in this plan, GHG emissions in Kentucky could actually be 20 percent lower in 2025 than our 1990 emissions.

A Renewable and Efficiency Portfolio Standard Will Be Established

We must launch our efforts by first focusing on improving energy efficiency in all sectors of Kentucky's economy and adopting practical cost-effective conservation practices. Initiatives to improve energy efficiency have little cost compared with the economic and environmental benefits to be gained. A Renewable and Efficiency Portfolio Standard (REPS) is proposed whereby 25 percent of Kentucky's energy needs in 2025 will be met by reductions through energy efficiency and conservation and through use of renewable resources. Energy efficiency alone will offset at least 18 percent of Kentucky's projected 2025 energy demand. This would allow us to meet 60

percent of our projected 2025 energy requirements through energy efficiency, before any new generation.

As part of the REPS, we will also significantly increase utilization of renewable energy resources within the commonwealth. Today, renewable energy accounts for only about three percent of Kentucky's entire energy portfolio (this includes biofuels such as ethanol and biodiesel and renewable energy used to generate electricity). We will develop our renewable energy resources by encouraging greater generation of electricity from such sources as wind, hydro, and solar, and by providing incentives for biomass production. Through the REPS, we will increase Kentucky's renewable resources to more than triple our current use by 2025. We will achieve this growth by relying on our domestic renewable resources, thereby growing jobs both within the "green collar" manufacturing sector and within our home-based agricultural sector

Strategy 1 of this plan details how and what is required for us to achieve a reduction of 18 percent in our projected energy needs by 2025. These actions target energy efficiency and conservation in homes, offices, government buildings, industries, and the transportation sector. As an integral part of the proposed REPS, *Strategy 1*, with its emphasis on energy efficiency and conservation, will be one of the key components of the state's actions to reduce greenhouse gases. See Figure 4, which illustrates the 39 million metric tons of reduced GHG emissions that will result from implementation of this strategy.

Strategy 2 strengthens the greenhouse gas reduction efforts, and is another element of the REPS. By targeting to the fullest extent development of Kentucky's renewable resources, including solar, wind, hydro, and biomass, Kentucky's energy portfolio will begin to take on more breadth and offer new economic and environmental opportunities.

The proposed REPS is designed to allow the commonwealth the opportunity to maximize our renewable energy resources within the state without forcing our utilities to purchase higher-priced out-of-state renewable energy. But even with this aggressive REPS, Kentucky will still need to look at our traditional energy source – coal – and other options such as nuclear.

An Alternative Transportation Fuels Standard Will Be Established

To transition away from dependence on foreign petroleum, Kentucky and the nation can turn to domestic resources. By implementing the strategies presented in this plan, Kentucky can displace 60 percent of its reliance on foreign petroleum by utilizing fuels derived from biomass and coal, and by plug-in hybrid vehicles. We can do this using existing infrastructure in such a way that we do not increase our net carbon dioxide emissions. As we have witnessed dramatic fluctuations in the price of oil during 2008, we should be reminded of our economic and energy security vulnerability that results from our growing dependence on imported oil. Our businesses, citizens, and government agencies cannot even plan adequate budgets in the face of such uncertainty over prices. The fact that lower prices in the latter part of 2008 were a reflection of worldwide recession should not bring a sense of relief.

In *Strategy 3*, which will be included in the REPS and the ATFS, we will develop Kentucky's biomass resources in a sustainable, environmentally sound and economically beneficial manner. While building on the state's successes with corn-based ethanol production and soy-based biodiesel, the state will be

positioned to take advantage of existing technologies that expand our options for producing environmentally friendly bio-based fuels from cellulosic biomass.

Even with aggressive energy efficiency and renewable energy efforts, the commonwealth will need other resources to meet growing energy demand. If we hope to reduce our dependence on foreign oil, we must turn to our domestic fossil fuel resources, especially our coal resources, by deploying advanced cleaner coal technologies. The reduction in carbon dioxide emissions by 2025, can occur despite the fact that we continue to utilize our coal resources (see Figure 4). We can do this by capturing and storing carbon dioxide emissions from existing coal-fired electric generating units and from newly developed coal-conversion industries that help meet our domestic transportation fuel and natural gas needs.

As another component of the ATFS, *Strategy 4* further develops the goals and objectives to establish a vibrant coal-derived liquid transportation fuels industry. These objectives have been clearly articulated by Kentucky's elected officials, and the action items in *Strategy 4* will help to ensure this industry has a viable future in the commonwealth. The resulting energy security and economic development opportunities are significant, and the coal-to-liquids industry will be key to the continued employment of coal miners within the commonwealth.

Kentucky Will Rely on New, Cleaner Technologies at Home

Equally important as weaning ourselves from imports of foreign oil is reducing our dependence on imported natural gas. *Strategy 5* establishes an action plan directed toward increased natural gas production in the commonwealth and production of synthetic natural gas from Kentucky's coal resources. Again, this initiative intends to build upon the intent of policymakers within Kentucky in recent years to promote coal-conversion technologies that supply Kentucky with liquid transportation fuels and synthetic natural gas.

For Kentucky to achieve its greenhouse gas reduction goals, deployment of carbon dioxide capture and storage technologies on a large scale is crucial. Kentucky must find ways to reduce carbon dioxide emissions while ensuring that we meet our growing energy needs. The action plan in *Strategy 6* will help Kentucky initiate aggressive carbon capture and storage projects, with a goal by 2025 that 50 percent of Kentucky's coal-based energy facilities will be equipped with carbon management technologies. These reductions, illustrated in Figure 4, also show how a combination of actions and technologies will be necessary to achieve carbon dioxide emissions reductions.

Another key component to reducing Kentucky's carbon dioxide emissions is deploying non-carbon dioxide emitting technologies to meet our baseload electricity generation needs in the future. One option that must be considered is nuclear power. Given the lengthy timeframe for planning and construction of nuclear power plants, it is prudent for Kentucky's citizens and policymakers to launch a serious discussion today of how we should pursue nuclear power. The uncertainty surrounding federal climate legislation, the feasibility of deploying large-scale CCS within the next couple of decades, and Kentucky's and the nation's growing demand for electricity require that we consider seriously our options regarding nuclear power. Figure 4 illustrates the carbon dioxide reductions that would result from effective utilization of nuclear power in Kentucky—approximately 30 percent of Kentucky's estimated demand can be met through nuclear generation by 2030.

The diagram to the right depicts the seven strategies encompassed in this comprehensive plan that addresses issues related to all energy sectors in Kentucky.



Underlying Goals:

- **Energy Security**
 - We will have stable, predictable energy costs and reliable energy supply
 - We will lead the way for coal's future to reduce U.S. dependence on foreign oil
- **Economic Prosperity**
 - Reliable and stably priced energy will provide a competitive advantage for economic development
 - Energy systems will be technology driven
- **Environmental Sustainability**
 - We are committed to reducing green house gases
 - We will maximize the benefits of our reduced carbon emissions
 - We will be viewed as an environmentally conscientious state

Strategy 1:

Improve the Energy Efficiency of Kentucky's Homes, Buildings, Industries and Transportation Fleet

GOAL **Energy efficiency will offset at least 18 percent of Kentucky's projected 2025 energy demand.**

Strategy 1 encompasses elements of Kentucky's proposed Renewable and Efficiency Portfolio Standard (REPS) and the Alternative Transportation Fuels Standard (ATFS).

The REPS states that "by 2025, Kentucky will derive at least 25 percent of its projected energy demand from energy efficiency, renewable energy and biofuels while continuing to produce safe, affordable and abundant food, feed and fiber."

The ATFS states that "by 2025, Kentucky can displace 60 percent of its reliance on foreign petroleum by utilizing fuels such as those derived from biomass and coal, plug-in hybrid vehicles, and compressed natural gas."

INTRODUCTION

Both nationally and worldwide, we are experiencing dramatic increases in costs for our traditional sources of energy – coal, natural gas and petroleum. Supply and demand are seeking new balance points at much higher price levels with devastating impacts in many regions of the world. In the United States, including Kentucky, the rates charged by electric utilities are increasing as a result of rising prices for coal and natural gas used to generate power.

Prices for coal, natural gas, and petroleum likely will continue to increase, and therefore consumers' energy bills will continue to rise. Most would agree that the era of cheap energy is over. The choice we face is to take no action and see large price increases, or to take prudent actions now and see smaller price increases. In the near term, energy efficiency and conservation represent the fastest, cleanest, most cost-effective, and most secure methods we have to reduce our growing demand for energy and to help us address issues surrounding global climate change.

Nationally, approximately 25 percent of total electricity usage can be saved cost-effectively, at an average cost of three cents or less per saved kilowatt-hour. New generation sources cost five cents or more per kilowatt-hour, making efficiency the lowest cost electricity resource (Laitner, 2007). A recent analysis conducted by La Capra Associates shows that Kentucky's marginal cost of electricity could increase by 15 to 65 percent with the implementation of federal climate change and greenhouse gas policies. Such increases further underscore the value of energy efficiency (Smith, 2007).

Although the terms energy efficiency and energy conservation are often used interchangeably, the two can have different meanings. Energy conservation typically refers to reducing the services energy provides from the levels that would normally be used. For instance, if you raise your

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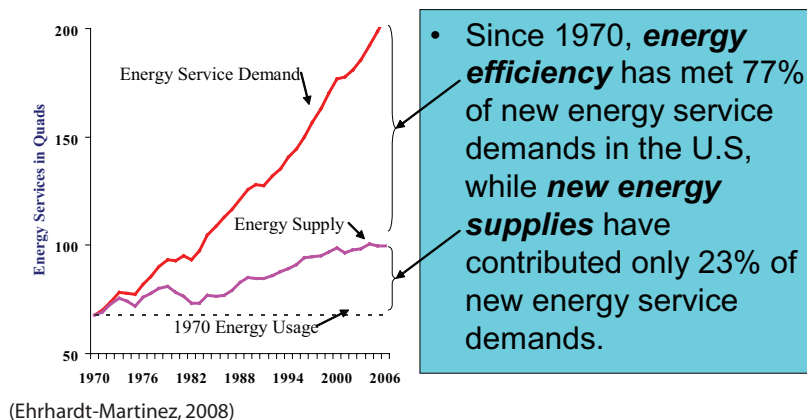


Figure 5: Contributions from Energy Efficiency Outstrip Contributions from New Supplies: 1970-2006

home's thermostat from 70 degrees to 74 degrees during the summer cooling season, then you are practicing energy conservation. On the other hand, if you replace an incandescent light bulb with a compact fluorescent bulb, you are increasing your energy efficiency.

Both energy conservation and energy efficiency concepts may also be placed into the broader context of "energy demand management." In a utility regulatory context, an example of a demand management program that is neither conservation nor energy efficiency would be a load shifting program. From the utility's point of view, having people change their consumption from peak times of day to off-peak times may allow the utility to avoid turning on a natural gas-fired generating peaking unit, which costs more to operate than a typical base load coal-fired generating unit. Such actions will save money since the higher cost unit is not being used.

Again using energy efficiency as an expression for all types of energy demand management programs, many studies have concluded that it has a key role in meeting our future energy demand. Stated conversely, energy efficiency can be thought of as an important source of incremental energy supply to help meet future energy needs.

According to the American Council for an Energy Efficient Economy (ACEEE), since 1970 energy efficiency has contributed more than three times as much energy to the U.S. economy as new supplies have contributed. In other

ENERGY STAR Schools in Kentucky

Kentucky is proving that energy-efficient schools make a difference by building schools that qualify for the ENERGY STAR label. Schools that earn the ENERGY STAR label use less energy, cost less to operate, lighten the load on the environment and improve the comfort and indoor air quality for building occupants. Kentucky has 34 buildings that have received the ENERGY STAR label, with 15 of those being public K-12 schools. These schools are some of the most energy-efficient facilities in the commonwealth. On average, these schools use as much as 33 percent less energy than a traditionally built school, and can save \$45,000 to \$50,000 in annual energy costs. ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy that helps save money and protect the environment through superior energy efficiency.

words, since 1970, based on projections of historical energy consumption increases, we would have had to build/discover and bring to market four times as much “new supply” of energy as we actually delivered to the market (Ehrhardt-Martinez, 2008).

Not only does energy efficiency result in savings today, the savings are compounded over time as energy prices continue to rise. Dollar for dollar, energy efficiency is one of the best energy investments Kentucky can make.

Energy efficiency can also provide significant benefits to the state and national economy. Energy efficiency improves business competitiveness, household savings and the environment. Green jobs, sometimes called green collar jobs, that result from investments in energy efficiency and renewable energy, can create opportunities for the economy as well. While additional Kentucky-specific research is necessary to estimate the job impact attributable to increased levels of energy efficiency or use of renewable energy sources, there are numerous studies that provide information on a national scale.

For example, a November 2007 study by the American Solar Energy Society showed that renewable energy and energy efficiency industries today generate nearly \$1 trillion in revenue in the United States and contribute more than \$150 billion in tax revenue at the federal, state and local levels (Bezdek, 2007).

The National Action Plan for Energy Efficiency (NAPEE), a national commitment to energy efficiency by more than 50 leading U.S. gas and electric utilities, utility regulators, and partner organizations, estimates that if utilities were to invest roughly \$7 billion a year in energy efficiency, this would leverage another \$20 to \$30 million in non-utility investment, yielding annual savings to consumers of some \$22 billion by 2017. These investment levels could result in the creation of nearly 300,000 jobs annually (Song, 2007).

Kentucky's investment in energy efficiency will not only reduce our emissions of greenhouse gases and dependency on oil from foreign sources but will serve to stimulate economic growth and new job creation. Thoughtful policies that encourage Kentuckians to consider and implement cost-effective energy efficiency measures will help Kentucky's economic outlook.

Kentucky's Current and Projected Energy Use Patterns

With our electricity rates among the lowest in the United States, it is not surprising that Kentucky's per

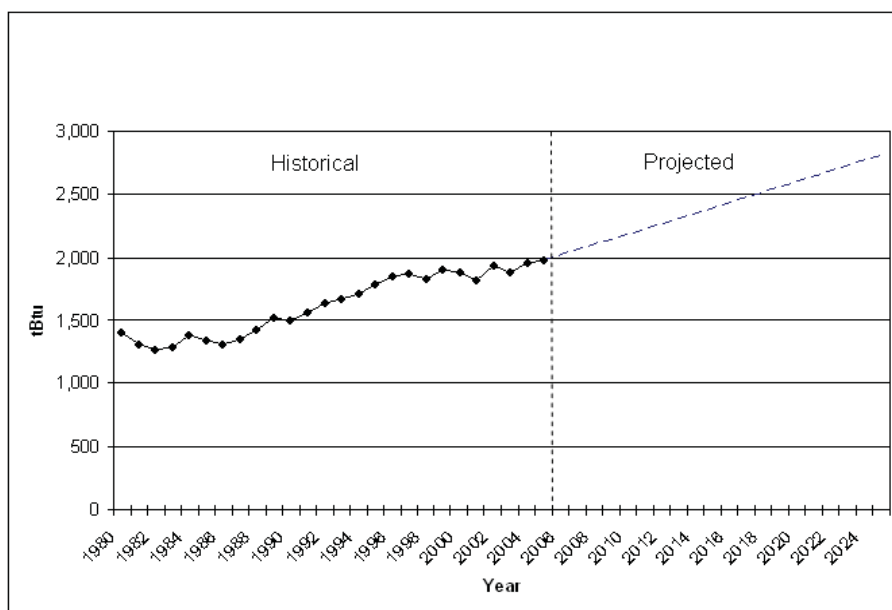
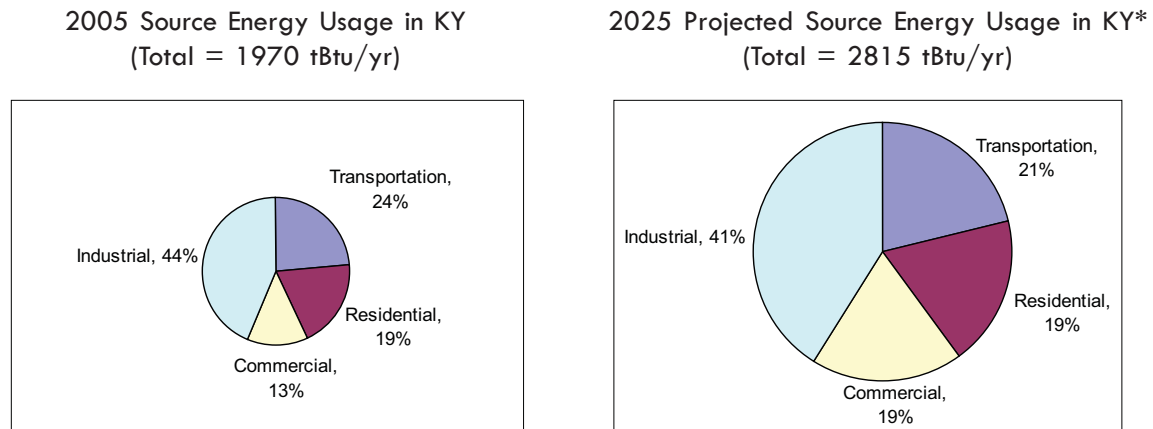


Figure 6: Total Energy Consumption 1980-2005, Projected to 2025 (EIA, 2005b)

capita consumption of residential electricity is among the highest in the country. Our low rates have tended to be a barrier to the adoption of effective energy efficiency practices in the state.

In 2005, total energy usage in Kentucky was the sixth highest per capita in the United States (EIA, 2005a). In the same year, the average expenditure per Kentuckian on energy was \$4,084, ranking the state ninth nationwide even though we ranked 45th nationwide in energy prices (dollars per million Btu). This discrepancy underscores the fact that Kentucky is an energy-intensive state on a per capita basis. In 2006, Kentucky's electrical use per industrial customer was 427 percent above the national average (ranking third highest); residential use per customer was 24 percent above the national average (sixth highest). These averages indicate that there is opportunity for energy efficiency in Kentucky.

Energy consumption in Kentucky has increased dramatically since 1980, and the trend toward increased consumption is expected to continue.



* Business As Usual – BAU projections assume energy efficiency and energy conservation continue at current levels but no new efficiencies or conservation initiatives are introduced.

Figure 7: 2005 Source Energy Usage in Kentucky and Projected to 2025

Table 1: Percent Increase from 2005 to 2025 of Source Energy Used

Source Energy Used in 2005 And Projected Use in 2025 (tBtu)			Percent Increase
Year	2005	2025	
Residential	370	536	45
Commercial	260	527	103
Industrial	863	1147	33
Transportation	477	605	27
TOTAL	1970	2815	43

(Colliver et al., 2008)

The EIA Annual Energy Outlook (AEO) gives projections for annual energy consumption through 2030 for the East South Central region of the United States. In order to use the AEO as the basis for the state's projected usage, Kentucky's fraction of the existing East South Central region usage was assumed to continue into the future (Colliver et al., 2008). The EIA updates its energy forecast on an annual basis; rather than continuously track the most recent forecast the AEO 2006 was used as the reference case.

"Source energy" is the energy content of the primary fuel and is a measure of energy before electric transmission and generation losses. Between 2005 and 2025 Kentucky's total source energy usage is projected to grow from 1,970 trillion Btu per year to 2,815 trillion Btu per year, an increase of over 43 percent, approximately 1.8 percent each year for the 20-year period in a business-as-usual scenario (see Figure 7). The commercial and residential sectors are predicted to experience the largest percentage growth in energy usage (Table 1) (Colliver et al., 2008).

Toyota is committed to the continuous improvement of energy performance by having systems in place to identify opportunities for energy savings. The company accomplishes this through their successful plant-wide energy assessments to find energy reduction opportunities. These assessments have allowed Toyota to continually improve their energy performance. Within the span of one year alone, 2005, Toyota decreased energy intensity eight percent while increasing production four percent (EPA, 2008a).

Conservation and Energy Efficiency in Context

With cost-effective programs in place, conservation and energy efficiency are projected to be the largest contributors to meeting our growing energy demand in 2025. Figure 8 shows that energy efficiency could offset up to 18 percent of our total energy, or 511 trillion Btu, in 2025. Stated another way, about 60 percent of our new energy requirements could be satisfied with energy efficiency, not new production. This is not unrealistic as the United States has met 77 percent of its new energy demands with energy efficiency since 1970 (Laitner, 2007).

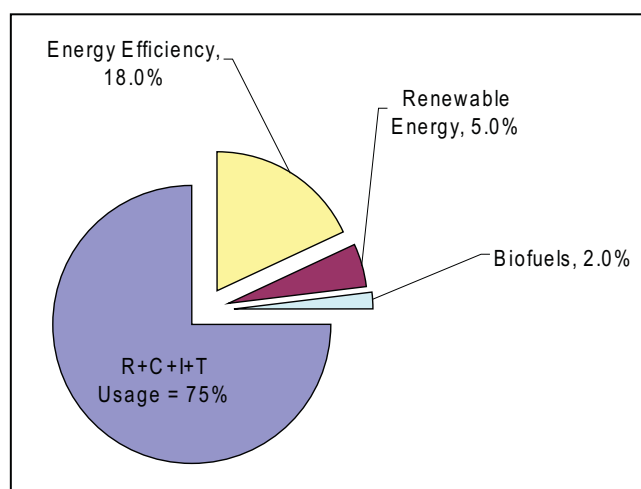


Figure 8: Projected Contribution of Energy Efficiency, Renewable Energy and Biofuels to meet Kentucky's Total 2025 Energy Demand (Total Demand=2815 tBtu)

Using an analysis by the University of Kentucky as a basis, energy efficiency in the residential, commercial and transportation sectors could offset about 10 percent of our projected 2025 energy demand; renewables five percent (*Strategy 2*); and biofuels another two percent (*Strategy 3*) (Colliver et al., 2008). The remaining eight percent in *Strategy 1* includes industrial, transportation and energy efficiency technologies not addressed in the University of Kentucky analysis. Additional analysis is needed to determine the total energy efficiency potential for the industrial sector in Kentucky.

The identification and implementation of energy efficiency programs is a dynamic process. Rising energy prices and technological advances significantly affect the cost-effectiveness of energy-efficiency programs. Industry and business must continuously reassess these variables along with business trends to find optimum energy efficiency solutions that help reduce operating costs.

Opportunities to Reduce Energy Consumption

Energy Efficiency Resource Standards

A growing number of states are adopting energy efficiency resource standards (EERS) or energy efficiency portfolio standards (EEPS), to help ensure that cost-effective energy efficiency measures for electricity and natural gas are being implemented.

Currently, 17 states have goals using EERS that quantify how much energy savings will be generated from energy efficiency measures. EERS consist of electric or natural gas energy-savings targets for utilities, often with flexibility to achieve the target through a market-based trading system. EERS encompass end-user energy-saving improvements that can include distribution system efficiency improvements, combined heat and power (CHP) systems, and other high-efficiency distributed generation systems (Nadel, 2006). In Kentucky, the Tennessee Valley Authority (TVA) established a voluntary energy efficiency target to reduce future systemwide demand by 1,200 megawatts by 2013 (EPA, 2008b) (Figure 9).



Notes: New Jersey and Michigan have pending EERS requirements.

(ACEEE, 2008)

Figure 9: State Energy Efficiency Resource Standard (EERS) Activity, May 2008

EERS require that energy providers meet a specific portion of their electricity and natural gas demand through energy efficiency. EERS are intended to help overcome the various barriers that keep utilities and other players from investing in cost-effective energy efficiency that several studies predict could meet up to 20 percent of the nation's energy demand, or about half of the expected demand growth (Nadel, 2004). However, in many states, market barriers, regulatory disincentives, or insufficient information about the benefits of energy efficiency keep utilities and other customers from investing in cost-effective energy efficiency to its full potential.

States have found that establishing explicit targets, based on sound analysis of technical and economic potential, can help reduce energy demand, cut emissions, help address concerns with system reliability and provide other energy-related benefits (EPA, 2006).

In some cases, states have combined EERS with additional policy measures such as demand-side management (DSM) programs, public benefit funds and different pricing structures that allow incentives for utilities to earn revenue in ways that are not entirely linked to additional sales. Aggressive EERS targets will require that all economic sectors be considered and addressed.

Under EERS, a state utility commission specifies numerical energy savings targets that natural gas and/or electricity service providers must meet, on an annual and sometimes cumulative basis. EERS can be set as a percentage of load growth or base year sales, or as a fixed number of units of energy savings (e.g., kilowatt-hour or Btu). Targets can also cover peak electricity demand (e.g., megawatts capacity). The appropriate EERS target depends upon a number of factors including the economically achievable energy efficiency potential, funding availability, emission reduction goals, and other issues including how to treat any existing energy efficiency requirements (EPA, 2006).

The implementation of an EERS occurs primarily through designated utilities. However, continued state involvement is important to oversee the development of implementation rules. In particular the state's role in evaluating measurement and verification (M&V) is critical to maintaining credibility for the market and commodity.

PUBLIC BENEFIT FUNDS

Establishing regulatory mechanisms and funding sources for utility programs to help achieve the efficiency resource goals is another key issue states have encountered. Different approaches have included one or more of the following: utilizing resources under a public benefit fund (PBF), allowing for cost recovery as part of utility rates, providing direct funding, and establishing regulatory provisions that allow new rate designs (EPA, 2006).

PBFs, also known as system benefits charges (SBCs), are typically created by levying a small charge on every customer's electricity and/or natural gas bill. These funds provide an annual revenue stream to fund energy efficiency programs. Currently, 30 states and Washington, D.C., provide nearly \$3 billion annually for energy efficiency and related programs via this mechanism. States with restructured as well as traditional electricity markets are using PBFs as a component of their energy efficiency, renewable energy and low-income portfolios. In Kentucky a PBF of 1mil per kilowatt-hour would generate approximately \$67 million annually, based on 2006 retail sales of 66,886 thousand megawatt-hours by Kentucky's regulated investor-owned and cooperative utilities.

The development of both utility-sponsored and non-utility-sponsored programs should be considered when designing a plan to achieve the EERS. Utility-sponsored programs are traditional demand-side management programs using cost recovery while non-utility-sponsored programs are those funded through other mechanisms (e.g., PBF).

A challenge for Kentucky to implement an EERS will be to ensure that it is applied equitably across the commonwealth and that both jurisdictional and non-jurisdictional energy service providers and their customers are considered. How best to approach this challenge will require further analysis and discussion between stakeholders, legislators, regulators and executive agencies.

As energy efficiency programs designed to achieve the EERS increase in sophistication and complexity there will be a demand for improved energy management protocols and control systems. These new protocols and systems will come as improvements and upgrades are made in the energy transmission infrastructure. Several states are already upgrading their energy transmission infrastructures through the implementation of “smart grid” technologies. These are technologies that enable consumers to choose what type of energy they receive, as well as having the ability to manage their own consumption habits through in-home automation. Consumers better understand how energy is used within their home or business, how much usage costs them, and the impact that energy usage has on the environment (Xcel Energy, 2008).

A “smart grid” is essentially an electric system that integrates the infrastructure, processes, devices, information and market structure so that energy can be generated, distributed, and consumed more efficiently and cost effectively; thereby achieving a more resilient, secure, reliable and environmentally benign energy system. “Smart grid” builds on many of the technologies already used by electric utilities but adds communication and control capabilities that will optimize the operation of the entire electrical grid. It is also positioned to take advantage of new technologies, such as plug-in hybrid electric vehicles, various forms of distributed generation, solar energy, smart metering, lighting management systems and distribution automation (NEMA, 2008).

The development of a new technologically advanced electric network will require additional resources and funding that must be evaluated and balanced against enhanced capabilities, reliability and overall benefit to the utility and their customers.

Beyond the benefits tied to reduced energy use, states have found EERS have a number of particular advantages as a policy approach (EPA, 2006). The advantages include:

- **Simplicity** - EERS create a straightforward resource acquisition target for energy providers.
- **Cost-Effectiveness** - Setting an energy efficiency requirement without explicitly setting aside a pool of funds challenges electricity and natural gas providers to meet the goal in the most cost-efficient manner.
- **Specificity** - By articulating a specific numeric target, EERS can be effective in illuminating how much energy efficiency will contribute to reaching goals of energy demand reduction as well as emission reductions and other public policy goals.
- **Economies of Scale** - The macro-level targets inherent in EERS allow energy providers to aggregate savings across enough end-uses and sectors to meet the overall savings goals cost-effectively. This helps address a fundamental barrier to energy efficiency resource development: the distributed nature of energy efficiency resources. Securing substantial energy-efficiency gains in every end-use and use sector involves millions of homes, offices, factories, and other facilities and thus can be difficult when approached at a micro-level.
- **Accountability** - Because utilities will have an measurement and verification protocol to follow, reliable estimates of actual savings can be developed. This feedback can lead to ongoing modifications to energy efficiency programs to make them more effective.

There is little doubt that energy prices will continue to climb. Higher energy prices will certainly be followed by significantly higher energy bills, unless policies are put in place to reduce energy demand and usage. There will be a cost associated with implementation of an EERS program. However, there will also be a payback.

Energy Efficiency Education, Outreach and Marketing

Energy efficiency outreach and education are critical to help consumers learn about the benefits of energy efficiency and to provide information on the array of products and services available to them to help reduce energy consumption.

There are many readily available, easy to implement, cost-effective methods and products that Kentucky residents and businesses can use to save energy and lower expenses. Unfortunately, many people are unaware of these products and services, or they do not fully understand the benefits to be gained from them.

For example, for some measures that are not currently cost-effective or that are more expensive to purchase up-front, the federal government may offer incentives to help bring down the initial cost. Unfortunately, many consumers might not know these incentives exist. In some cases, certain energy efficiency measures are required by law, as in the case of the Kentucky Building Code (KBC) and the Kentucky Residential Code (KRC), which requires certain standards be incorporated into building practices. Still, many of these methods and products have not been widely adopted in Kentucky. Increasing public awareness of the need to strengthen energy provisions in the KBC and KRC, along with enhanced code enforcement, will improve the energy efficiency of Kentucky's buildings.

A multi-faceted and wide-ranging public information campaign would increase the knowledge of energy consumers and help them make better educated decisions about energy consumption and equipment purchases.

Energy Efficiency Leadership by State Government

State government can improve its building and vehicle energy efficiency and, at the same time, substantially cuts its costs. Activities already being initiated by the

There is little doubt that energy prices will continue to climb. Higher energy prices will certainly be followed by significantly higher energy bills, unless policies are put in place to reduce energy demand and usage. There will be a cost associated with implementation of an EERS program. However, there will also be a payback.

Kentucky Energy Efficiency Program for Schools (KEEPS)

In partnership with the University of Louisville, the Energy and Environment Cabinet (EEC) supports the Kentucky Energy Efficiency Program for Schools (KEEPS), which helps participating schools and universities improve energy efficiency by offering tools, training and expertise. KEEPS allows participants to analyze and understand their energy consumption, which includes everything from lighting usage, heating and cooling issues to natural gas consumption. The 2008 Regular Session of the General Assembly passed HB 2, which requires that all 174 Kentucky public school districts enroll in the KEEPS program by January, 2010. Within the past two years, more than \$160,000 in grant funding has gone to support KEEPS. An example of the program's effectiveness is Bullitt County school district, which joined KEEPS in 2006 as a pilot program. During the 2007-2008 school year, district electricity consumption was reduced by 11 percent (a savings of approximately \$180,000) and natural gas usage was reduced by seven percent. The district's total avoided costs including account credits equaled nearly \$246,000 for the 2007-2008 school year.

Finance and Administration Cabinet through the “Green Team” program must become more robust and must be adopted as the normal course of doing business. Additionally, as a large energy buyer, the state can boost the markets for advanced technologies and clean energy sources. The state should adopt and implement energy management practices and utilize renewable fuels and resources where doing so has a life-cycle cost benefit or can assist in transforming the market for these practices and technologies. See Near-Term Action 1 for details on state government actions.

Transportation Energy Efficiency

Transportation is closely tied to Kentucky's economy, security and health. High prices for fuel divert household dollars from other uses, traffic congestion erodes worker productivity, and prices climb for a broad range of consumer goods, including food. In the summer of 2008, crude oil prices set record highs.

One approach to reduce the cost, health and environmental impact of the transportation sector is to adopt technologies that make the vehicle-based transportation system more fuel efficient. Hybrid gasoline-electric vehicle (HEV) and plug-in hybrid electric (PHEV) technologies use less fuel per passenger-mile or ton-mile (freight), and alternative power sources at rest stops reduce the need for truck drivers to use fuel to idle their engines during overnight stays. Other transportation technologies help traffic flow more smoothly, enabling vehicles to use fuel only when necessary. All of these measures are in use and available in Kentucky, and they offer ways to reduce fuel costs and consumption. Technological advances in other transportation modes (e.g., rail and air) will also contribute to reduced fuel consumption.

“Smart” traffic control makes the flow of traffic more efficient through real-time monitoring, synchronized traffic devices and other technologies that reduce stopping and idling. These technologies include traffic cameras, sensors and controls that respond to traffic activity, and synchronized traffic signals or roadway configurations (roundabouts) that reduce idling (Georgia, 2006).

Efficient transportation technologies, such as fuel efficient vehicles, also significantly reduce the cost, health and environmental impact of the current transportation system. Transportation demand management (TDM) addresses the increasing demand for mobility by promoting alternatives to vehicle use, particularly single-occupancy vehicle use. Carpooling, vanpooling, telecommuting, public transit, walking and bicycling are TDM measures that promote conservation of transportation energy resources (Georgia, 2006).

In addition to these measures, the 2007 Energy Independence and Security Act will help Kentucky improve its overall vehicle fuel efficiency. The act requires the U.S. Department of Transportation to set tougher fuel economy standards, starting with model year 2011, until the standards achieve a combined average fuel economy for model year 2020 of at least 35 miles per gallon (MPG) (DOE, 2008).

ACHIEVING THE GOAL

Energy efficiency will offset at least 18 percent of Kentucky's projected 2025 energy demand.

Four action items have been identified to achieve this goal.

- An energy efficiency program for state government that has aggressive internal energy savings targets will be implemented. This program is important as it establishes a leadership role for state government.
- As part of an overall REPS, an Energy Efficiency Resource Standard (EERS) for electric and natural gas utilities will be set with a goal of reducing energy consumption by at least 16 percent below currently projected 2025 energy consumption. To achieve the EERS a combination of both utility-sponsored and non-utility-sponsored energy efficiency programs will be developed and implemented.
- Kentucky will have a strong education, outreach and marketing component that will support all of its other energy efficiency activities. Specific savings are not being attributed to this activity since it will support all of the efficiency and conservation efforts.
- Transportation energy efficiency programs and vehicle fuel economy initiatives will contribute at least another two percent representing a savings of approximately 500 million gallons of motor fuel annually. This percentage may be significantly large with efficiency improvements in air and rail transportation, and with greater adoption of plug-in hybrid vehicles and fuel-efficient diesel engine vehicles.

Near-Term Actions (1-3 years)

1. Kentucky will improve the energy efficiency of state-supported facilities and the fleet fuel efficiency of state-owned vehicles. State government will aggressively pursue achieving the requirements outlined in Sections 4-8, House Bill 2 and seek other opportunities that will reduce the energy consumed by all state-financed or state-owned buildings and vehicles.

To measure progress toward improving energy efficiency in state government, the following targets are recommended:

- By 2015, state-supported facilities will reduce energy consumption by 15 percent measured in energy per square foot per year using 2009 consumption as the baseline year. By 2025, state-supported facilities will reduce energy consumption by 25 percent as compared to the 2009 baseline year.
- By 2015, the state vehicle fleet fuel economy measured in miles-per-gallon will improve by 30 percent, or by approximately five miles-per-gallon as compared to a 2007 baseline. By 2025, the state vehicle fleet fuel economy will improve by 50 percent as compared to the 2007 baseline.

The Energy and Environment Cabinet (EEC) will have overall program responsibility to ensure that these goals are achieved and coordinated with state agencies, post-secondary schools and K-12 schools.

The Finance and Administration Cabinet (FAC) will have a critical role in measuring and tracking progress, building and operating high performance facilities compliant with House Bill 2 standards, and procuring highly fuel-efficient vehicles for the state fleet. The High Performance Building Advisory Committee created in House Bill 2 will set aggressive building performance standards. The Kentucky Council on Post-Secondary Education, the Kentucky Department of Education and the Education Cabinet will also serve in support capacity to reduce energy usage in their respective school facilities.

The Judicial Branch will also implement actions that support the state energy goals for the facilities that they build, maintain or for which they pay energy costs.

The EEC in collaboration with state agencies, post-secondary schools and K-12 schools will develop a comprehensive energy management plan to achieve the state goals. The energy management plan will establish and support the following initiatives.

Buildings

- Establish an interagency energy management council consisting of representatives from all cabinet-level state agencies, the Kentucky Council on Post-Secondary Education and the Kentucky Department of Education to coordinate implementation of the plan. The EEC Secretary will chair the council.
- Leverage federal and state funding resources to support procurement of a computer-based energy management system that will allow FAC to track and measure energy consumption, develop benchmarks and evaluate progress in state-owned facilities.
- Require that all new state-funded buildings be commissioned, a quality assurance process that verifies and documents that a facility and all of its subsystems are operating as intended by the building owner and as designed by the building architects and engineers.
- Strictly ensure that new building construction complies with whole building life-cycle cost analysis as prescribed by KRS 56.778.
- Aggressively pursue the use of energy savings performance contracts (ESPC) as a financing mechanism for energy efficiency renovation projects. By January 2010, all state-owned buildings of 20,000 square feet or larger will be evaluated by the FAC to determine if they are viable candidates for ESPC. All viable candidates will be included in an ESPC by January 2012.
- Identify fiscal strategies that will allow capital construction budgets to be augmented by long-term energy efficiency savings from operational budgets.
- Establish a grants program for public K-12 school districts that will help offset the cost differential, if any, associated with designing and constructing a new or renovated school to ENERGY STAR or Leadership in Energy and Environmental Design (LEED) standards.

Procurement

- Establish minimum energy performance criteria for appliance and equipment purchases. ENERGY STAR appliances, lighting products and other products will be purchased when available.
- Develop purchasing criteria for the commonwealth to increase the overall fuel efficiency of the vehicles in its state fleet.

Vehicle Fleet

- Reduce the state fleet inventory to the minimum level feasible while still meeting agency travel needs.
- Downsize fleet vehicles to the smallest class possible while still meeting agency mission requirements. Purchase the most fuel-efficient vehicle having the best value within the class.

- Integrate cost-effective advanced technologies (e.g., Geographic Information System) into the management of Kentucky's vehicle fleet to reduce fuel consumption and improve overall asset control. The FAC should continue and expand current efforts to reduce fuel consumption of the state vehicle fleet.
2. Establish an Energy Efficiency Resource Standard (EERS) with the goal of reducing energy consumption by at least 16 percent below projected 2025 energy consumption.

As components of the EERS:

- Kentucky will implement recommendations from the House Bill 1, Section 50 report to authorize the Kentucky Public Service Commission (PSC) to develop model demand-side management programs and review, evaluate and approve DSM programs for regulated utilities. Developing and approving aggressive DSM programs will be the first step toward achieving the EERS goal. These recommendations include: amending the existing DSM statute (KRS 278.285) to broaden the PSC's authority to require utilities to implement specific DSM programs; clarify and standardize rules governing industrial customer exclusion from utility DSM programs; establishing standards for the evaluation of both proposed and ongoing DSM programs; and provide for additional PSC staffing and relevant training necessary to support increased activities associated with Integrated Resource Planning, DSM, Certificate of Public Convenience and Necessity, and other issues.
- The EEC and PSC will conduct a study analyzing the energy efficiency potential of Kentucky's residential, commercial, industrial and transportation sectors.
- The PSC and EEC will determine the impact, surcharge amount and cost of establishing a public benefit fund to support non-utility sponsored energy efficiency programs; education, outreach and marketing programs; and the renewable energy programs outlined in *Strategy 2*.
- The EEC and PSC will conduct a study that analyzes how a PBF or EERS could be applied to both jurisdictional and non-jurisdictional energy service providers and their customers.
- The PSC will conduct a proceeding to evaluate the impact and ramifications of setting an EERS goal of reducing energy consumption by at least 16 percent below projected 2025 energy consumption levels. The proceeding will address the following issues:
 - Identify the mix of programs that should be implemented to cost-effectively achieve the EERS by 2025.
 - Define a framework and specific tests for determining which efficiency programs and policies are cost-effective.
 - Develop and implement a plan for the recommended programs.
 - Estimate the cost to attain the energy consumption reduction goal.
- The EEC will identify and recommend new tax incentives that will further enhance energy efficiency in the commonwealth.

3. The EEC, in conjunction with other state agencies and energy service providers, will conduct a vigorous and ongoing public energy efficiency awareness and education program.
 - The public awareness program will target both the general public and specific consuming sectors (agricultural, transportation, commercial, schools, etc.). The program will utilize partnerships, for instance with the state's universities and technical colleges and organizations such as, but not limited to, the Kentucky Cooperative Extension Service, the National Energy Education Development Project, Kentucky League of Cities, and the Kentucky Pollution Prevention Center, to increase outreach capabilities. It will aggressively market and promote the efficiency tax incentives in House Bill 2.
 - The EEC's development of a Kentucky public energy efficiency awareness and education program will include the following:
 - Form focus groups to assist in the development of survey design.
 - Determine baseline attitudes, practices and awareness of energy efficiency, conservation, use of renewable energy and biofuels through surveys.
 - Specify objectives and outcomes.
 - Develop the message, training outcomes and select media.
 - Implement the education, outreach and marketing program.
 - Assess results and make corrections to increase effectiveness.
 - The EEC will determine the benefits of establishing energy efficiency Centers of Excellence to deploy energy efficiency technology into all sectors of Kentucky's economy.
4. Kentucky will reduce continued reliance on imported oil by creating incentives that develop a robust plug-in hybrid electric vehicle and highly fuel-efficient vehicle market in Kentucky.
 - Support transportation demand management efforts that significantly reduce vehicle miles traveled (VMT) and utilize telecommunication technologies to reduce travel.
 - The EEC will identify and recommend incentives for plug-in hybrid electric vehicles and highly fuel-efficient vehicles in Kentucky to increase market share.
 - Implement "smart" traffic control and transportation demand management strategies through actions by the Kentucky Transportation Cabinet.
 - Develop and grow partnerships with utilities, universities and manufacturers that support an emerging highly-efficient vehicle industry in Kentucky.
 - The EEC will examine the impact of a vehicle carbon emissions standard and assessment for automobiles, SUV's and pick ups.

Mid-Term Actions (4-7 years)

1. A policy for "smart grid" development will be established for Kentucky. Electric utilities must work in concert with the PSC to develop "smart grid" networks and technologies that will facilitate the next generation of DSM programs.

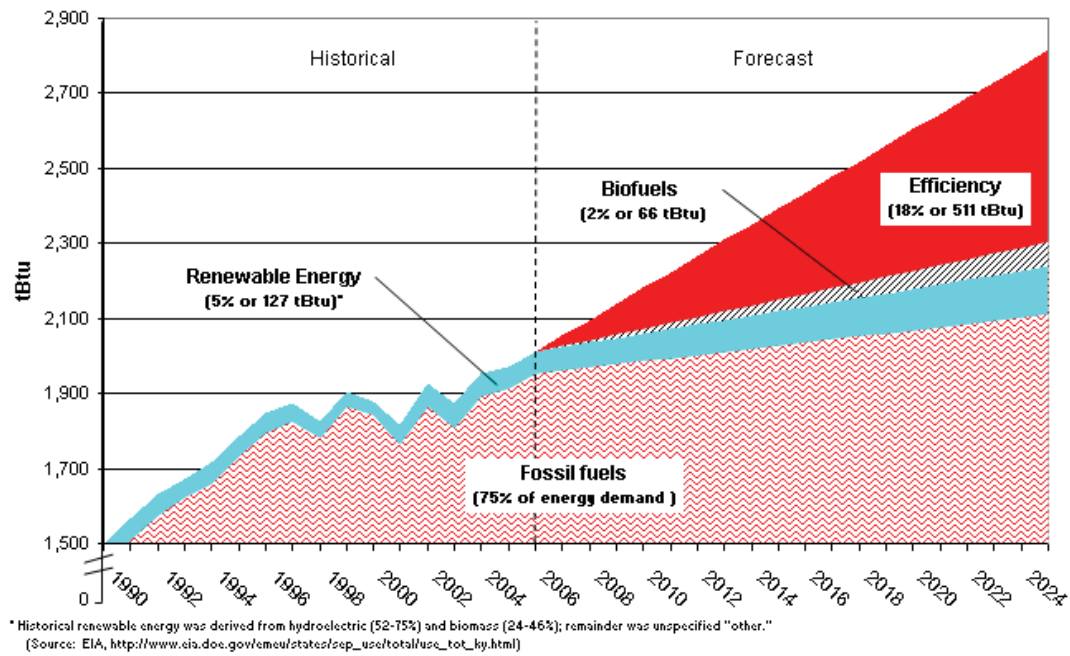


Figure 10: Kentucky Total Energy Consumption and Savings Potential (2025 Goal)

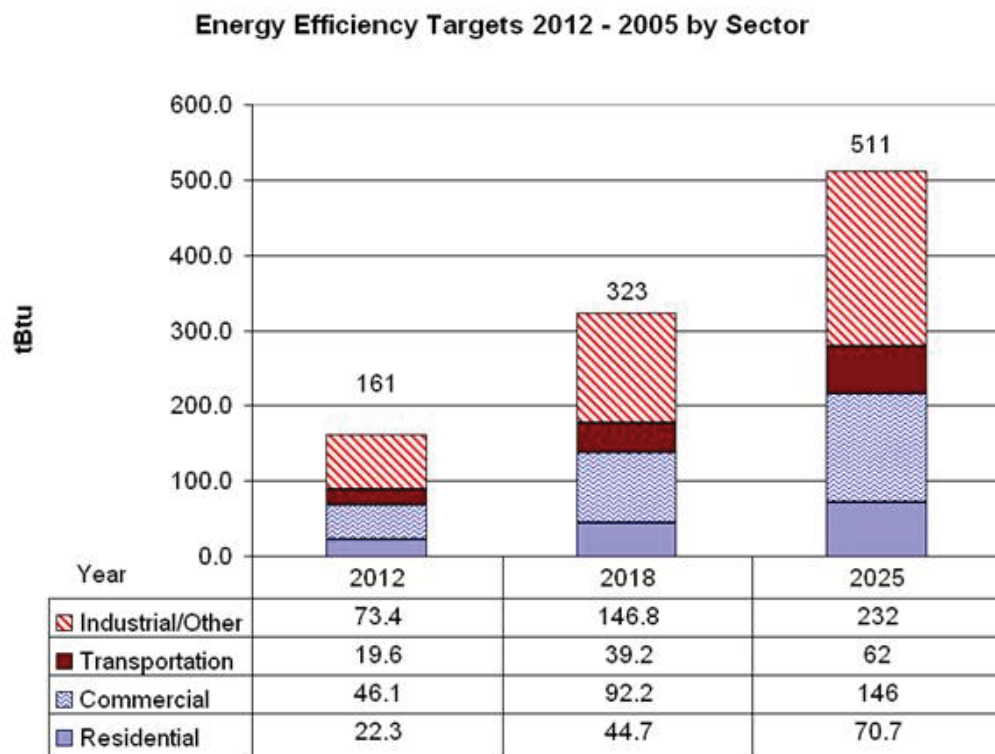


Figure 11: Energy Efficiency Targets 2012-2025 by Sector

2. The PSC and EEC will evaluate rate design and ratemaking alternatives to enhance the impact of cost-effective energy efficiencies.

Long-Term Actions (>7 years)

1. Kentucky will continue to enhance its electric power system, from power generation to customer appliances, by integrating advanced "smart grid" technologies and communication systems to help Kentuckians better manage and control their energy demand and costs.
2. Kentucky will reevaluate the Energy Efficiency Resource Standard (EERS) goal of reducing source energy consumption by at least 16 percent below projected 2025 energy consumption to determine if additional reductions are achievable.

IMPLEMENTATION SCHEDULE

It is estimated that the energy efficiency measures outlined above can reduce Kentucky's projected "Business-As-Usual" (BAU) total source energy consumption in 2025 by at least 18 percent. Figures 10 and 11 identify *Strategy 1* targets for 2012 and 2018 as well. With energy efficiency targets, it is frequently difficult to determine the impact certain actions will have on the state's energy mix. The rate of adoption of energy efficient practices in the private sector will be greatly influenced by market prices. If energy prices continue to escalate at recent rates, adoption of energy efficient techniques and technologies will be greatly accelerated. If, on the other hand, energy prices were to decline sharply we would probably return to making decisions about energy based solely on energy price, and not on the true cost of energy, a cost that takes into account the very real impacts our energy consumption has long term on our environment, our economy and our national security.

Implementing energy efficiency is a dynamic and on-going process that changes with advances in technology and new economic markets.

In the near term, ensuring the PSC has adequate authority to spur expansion of DSM programs and providing authority for implementation of an EERS, along with implementation of effective public education and outreach initiatives, will help to accelerate early adoption of energy efficiency practices.

With those actions related to state government buildings and fleet vehicles, the state has direct control. Therefore, the targets established for state government will be more readily measurable. The High Performance Building Advisory Committee will recommend standards and regulations for high performance buildings pursuant to KRS 56.777. The FAC will promulgate regulations so that beginning July 1, 2009, all construction or renovation of public buildings for which 50 percent or more of the total capital cost is paid by the commonwealth will be designed and constructed, or renovated, to meet the high-performance building standards. Actions by the FAC and EEC to increase the fuel efficiency of the state's vehicle fleet will be put into action by October 2009.

By October 2009 the EEC will complete a plan designed to increase the market share of highly fuel-efficient vehicles in Kentucky using state incentives. This plan will be presented to the 2010 legislative session for consideration. Included in the plan will be recommended incentives designed to increase the market share of plug-in hybrid electric vehicles and highly fuel efficient vehicles in Kentucky.

The EEC will seek funding to conduct a study on the impact of establishing a vehicle carbon emissions standard and assessment for automobiles, SUV's and pick up trucks.

ENVIRONMENTAL BENEFITS & LIMITATIONS

The estimated 511 trillion Btu reduction in projected 2025 source energy consumption attributed to energy efficiency alone will result in a reduction of 39 million metric tons of carbon dioxide from the Business-As-Usual forecast, assuming there is no change in our energy portfolio mix from the present. This calculation is based on Kentucky's energy consumption profile as of 2005.

The environmental benefits of aggressively implementing cost-effective energy demand management programs are significant, though difficult to quantify. Cost-effective energy conservation programs have an immediate monetary effect by reducing energy related expenditures today. Taken together, energy efficiency programs will perpetuate the savings over time as long as people continue to conserve. While most cost-effective energy efficiency programs may require a greater up-front expenditure than conservation programs, they will result in ongoing savings with no further action required by the consumer.

To the extent that Kentucky's energy demand management programs are successful, the incremental insult we do to the environment is minimized. Also, when federal greenhouse gas mitigation legislation occurs, energy efficiency will benefit Kentuckians by helping to reduce the production of these gases.

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Strategy 2:

Increase Kentucky's Use of Renewable Energy

GOAL **Goal: By 2025, Kentucky's renewable energy generation will triple to provide the equivalent of 1,000 megawatts of clean energy while continuing to produce safe, abundant, and affordable food, feed and fiber.**

The goal for *Strategy 2* is part of Kentucky's Renewable Energy and Energy Efficiency Portfolio Standard (REPS) that states that "by 2025, Kentucky will derive at least 25 percent of its projected energy demand from energy efficiency, renewable energy and biofuels while continuing to produce safe, affordable and abundant food, feed and fiber."

INTRODUCTION

Energy from renewable resources benefits the environment while creating economic opportunities – the "green collar" jobs – for businesses, industry and rural communities. Renewable energy is one component of a three-part vision (*Strategies 1, 2 and 3*) to provide 25 percent of Kentucky's energy needs by 2025 through energy efficiency, renewable energy and biofuels. To achieve this goal, the commonwealth must aggressively invest in the development of its renewable energy resources.

Renewable energy provides users, utilities, and communities many benefits beyond its direct energy services. These include:

- Distributed energy security – renewable energy systems operate on a smaller scale than centralized power plants and can be dispersed throughout transmission infrastructures.
- Energy independence – energy generated from renewable resources reduces the state's reliance on imported oil and natural gas.
- Improved environmental quality – relative to conventional power production, renewable energy systems reduce air pollutants, generate less thermal pollution and emit fewer greenhouse gases into the atmosphere.
- Economic investment – developing renewable energy markets diversifies local economies and creates employment opportunities for research, manufacturing and businesses.
- Job creation – growing the renewable energy sector will bring new technologies to market and create new "green collar" jobs.

Renewable energy refers to energy resources that are naturally replenishing and virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time (EIA, 2008). Examples of renewable energy resources in Kentucky include hydroelectric, landfill gas, biomass, solar and wind energy. For discussion in this strategy, renewable energy does not include biofuels derived from plant materials, which are discussed separately in *Strategy 3*.

Kentucky's Renewable Energy Today

Kentucky's current use of renewable energy resources is limited. According to the EIA, of the 98.8 million megawatt hours of electricity produced in Kentucky in 2006, 92.3 percent was from coal-

fired sources, 2.6 percent from hydroelectric stations and 0.5 percent from other renewable resources (EIA, 2008b).

As shown in Table 2, renewable electricity generation in Kentucky today is dominated by hydroelectric resources (85 percent) with smaller amounts provided by wood waste (12 percent) and landfill methane (three percent) utilization. Kentucky does not have readily accessible reservoirs of steam, hot water or hot dry rocks for the production of electricity from geothermal resources.

Table 2: Kentucky Renewable Electric Power Industry Statistics (EIA, 2008b)

2006 Generation	Thousand Megawatt-Hours	Percent of State Total
Total Renewable Net Generation	3,052	3.1
Geothermal	-	-
Hydro Conventional	2,592	2.6
Solar	-	-
Wind	-	-
Wood/Wood Waste	370	0.4
MSW Biogenic/Landfill Gas [†]	88	0.1
Other Biomass	2	-

[†]Kentucky has no significant generation from municipal solid waste (MSW).

Kentucky's Renewable Energy Opportunities

Relative to other parts of the nation, Kentucky does not have significant sources of utility-scale renewable energy. Biomass and hydropower have the greatest potential for high capacity applications, but the state's limited exposure to strong winds, clear sunshine and deep waters implies that the majority of renewable energy systems will be widely distributed and relatively small in scale.

Solar Energy

Kentucky does not receive sufficient direct sunlight to make concentrating solar power a viable option today, but it does receive ample amounts of solar radiation for photovoltaic and solar heating applications (U.S. Department of Energy, Alternative Energy Resources in Kentucky). In this regard, the lack of significant development of solar energy in Kentucky is not because of a lack of solar energy resource, but rather, a reflection of historical economic conditions which have favored fossil-based energy resources.

The solar resources available to Kentucky and much of the United States greatly exceed those of Germany, which leads the world with grid-tied photovoltaic installations, reaching 1,328 megawatts in 2007. Perhaps even more significant, over 40 percent of the German market consists of systems below ten kilowatt capacity (Solarbuzz, 2008 Report).

Solar Photovoltaic Electricity

The state's primary energy consumption in 2025 could be reduced by 12.6 trillion Btu through the widespread deployment of solar photovoltaic (PV) systems. A report from the University of

Kentucky estimates that widespread deployment of 470 megawatts of solar photovoltaic electricity could reduce the state's primary energy consumption in 2025 by 6.3 trillion Btu if 6-kilowatt systems were installed on one out of every five new homes built between 2008 and 2025 (Colliver et al., 2008). Although a similar analysis was not conducted for commercial and industrial sectors, it is reasonable to assume that installed capacity in these sectors would meet or exceed residential growth (SEIA, 2008).

A PV solar capacity of 940 megawatts is high by today's standards, however there are strong signs of explosive growth and investment in the U.S. solar industry. Between 2001 and 2006, domestic shipments of photovoltaic cells and modules increased an average of 50 percent each year (EIA, 2007b) and, whereas approximately 150 megawatts of solar PV was installed in the U.S. in 2007, an additional 800 to 1,500 megawatts of PV capacity is expected each year by 2011 (Koot, 2008).

In Kentucky, a 6-kilowatt grid-tied PV system could be expected to generate about 7,500 kilowatt-hours of electricity over the course of a year. In a region where household electricity consumption averages nearly 1,200 kilowatt-hours per month, approximately half of a home's annual electricity consumption would come from solar power (EIA, 2001). Today, solar PV systems cost about \$7-\$10 per watt of capacity installed. Thus a 6-kilowatt system would be on the order of \$50,000 without incentives or tax credits. Solar PV systems are eligible for a federal tax credit of 30 percent of the system costs. The cost of photovoltaic energy is high today, but newer more efficient solar cells are coming to market to help lower prices. The goal of the DOE's Solar America Initiative is to make solar cost-competitive with conventional electricity by reducing residential solar costs from 32¢ per kilowatt-hour in 2005 to 10¢ per kilowatt-hour by 2015 (DOE, 2008b).

Many state and local governments are pursuing PV installations on public buildings. To do this successfully, sound public policy, financial incentives, and committed program administrators are required. The most common benefits associated with public-sector solar programs include (Cory et al., 2008):

- PV can reduce utility peak summer demand.
- PV offers predictability of future utility expenses.
- PV reduces greenhouse gas (GHG) emissions.
- Public-sector PV stimulates the market and motivates other sectors to deploy solar.
- PV promotes the creation of local jobs.
- PV can provide emergency power benefits for critical municipal services during and directly after a disruption to the electrical grid.

Solar Thermal Hot Water

Energy used for water heating is a significant portion of the total energy demand in the commercial and residential sectors. In 2004, water heating in the residential sector consumed about 23 percent of all residential natural gas use, eight percent of all residential electricity use, and about 12 percent of total residential energy expenditures. Nationwide, about eight percent of all end-use natural gas is used to heat water in commercial and residential buildings. Solar water heating (SWH), which uses the sun to heat water directly or via a heat-transfer fluid in a collector, may be particularly important in its ability to reduce natural gas use (Denholm, 2007).

According to the University of Kentucky analysis, if one in five new housing units built between 2008 and 2025 includes solar water heating, the state could reduce its primary energy consumption in 2025 by 2.0 trillion Btu. Many non-residential applications also exist, including swimming pool heating, laundromats, hotels, dormitories, multi-family dwellings, and places with significant food preparation or processing. In total, these applications could amount to 70 percent of residential capacity (McMullen et al., 2008), bringing the total potential for solar water heating in Kentucky to 3.4 trillion Btu.

Wind Energy

Electricity generated from wind is becoming one of the least costly and most readily deployed options for new generation. In 2007, wind projects accounted for nearly 30 percent of all new power generating capacity in the United States. A 2008 report by the U.S. Department of Energy finds that the United States possesses enough affordable resources to contribute 20 percent wind energy to the nation's electricity supply by 2030 (DOE, 2008c).

The Wind Energy Resource Atlas of the United States associates most areas of Kentucky with a class 1 or class 2 wind power designation. A wind power class represents a range of wind power densities (W/m^2) that is likely to be encountered at an exposed site in the area. Large wind turbine applications require class 3 or better wind power. Class 2 areas are considered marginal and class 1 areas are generally unsuitable. Small areas of class 3 wind power are found along the mountain ridges in the extreme southeastern part of Kentucky.

Citing data from a 1991 study by the U.S. Department of Energy's Pacific Northwest National Laboratory, the American Wind Energy Association estimates that Kentucky has 19 square miles of class 3+ areas that are not under land-use or environmental restrictions. Developing these areas and accounting for the potential of small wind systems, Kentucky is believed to have the capacity to generate 34 megawatts of wind energy power on average. Operating over the course of a year, this renewable resource could reduce the state's (primary) energy consumption by 3.2 trillion Btu (Colliver et al., 2008).

Large-scale wind projects in other states have encountered resistance to such issues as:

- Avian and bat mortality rates along migratory routes.
- Sight line obstructions of notable vistas.
- Arbitration of property easements and downstream wind shielding.
- Adverse effects on localized temperature and moisture, especially around agricultural lands.

These issues are likely to diminish in proportion to the smaller size of the wind farms anticipated in Kentucky, but further consideration is justified in order to facilitate development of the wind industry in the state.

Combined Heat and Power

In 2001, the Domtar paper mill near Hawesville, KY installed a combined heat and power system fueled almost entirely from biomass. The system has the capacity to produce 88 megawatts of electricity and one million pounds of steam per hour by burning "black liquor" and other wood byproducts from the plant. Capable of operating at almost 86 percent efficiency, the integrated system requires 23 percent less fuel than typical onsite thermal generation and purchased electricity. The project was recognized by the U.S. Environmental Protection Agency and the Department of Energy with a 2005 Energy Star Combined Heat and Power (CHP) Award.

Biomass Energy

Biomass is plant matter such as trees, grasses, agricultural crops, or other biological material. It can be used as a solid fuel, or converted into liquid or gaseous forms for the production of electric power, heat, chemicals or fuels. Biomass-based electricity generation is considered a relatively cost-effective renewable technology for Kentucky, but the economics generally require placement of the electric generation facility near the feedstock fuel source.

Municipal solid waste (MSW) power plants burn solid refuse from relatively large urban centers. While this type of power plant can be economically feasible, many concerns have been raised about the environmental safety of burning a multitude of domestic, commercial and industrial waste products. This risk can be mitigated by using relatively homogenous waste streams, such as scrap from manufacturing processes, or by presorting the waste content. Kentucky burns negligible amounts of MSW for the generation of electricity.

Landfill gas (LFG) power plants are a variant of MSW technology, where gas from the decomposition of waste is used to fire turbines for electric generation. Municipal solid waste landfills are the second largest source of human-related methane emissions in the United States, accounting for nearly 23 percent of these emissions in 2006. At the same time, methane emissions from landfills represent a lost opportunity to capture and use a significant energy resource. Landfill gas consists of about 50 percent methane, the primary component of natural gas, about 50 percent carbon dioxide, and a small amount of non-methane organic compounds. Using LFG helps to reduce odors and other hazards associated with LFG emissions, and it helps prevent methane from migrating into the atmosphere and contributing to local smog and global climate change (EPA, 2008).

Kentucky has five active LFG power plants and a sixth project is under construction. The five active sites have a combined generating capacity of 16 megawatts (EPA, 2008b). The state's largest landfill, Louisville's Outer Loop, diverts a portion of its methane gas for direct use in a nearby industrial park. An additional 18 candidate sites and 12 potential sites are identified in the EPA's database. The theoretical potential of these resources could reduce the state's energy consumption by 5.9 trillion Btu (Colliver et al., 2008).

The decomposition that occurs underground in landfills can be engineered using anaerobic digester (AD) systems. Anaerobic digesters, often referred to as methane digesters, are amenable to biomass resources having high moisture contents. Byproducts from Kentucky's wastewater treatment facilities, ethanol and distiller industries and livestock operations could be converted into biogas using AD technology. Besides energy production, anaerobic digesters offer other benefits including odor reduction, reduced greenhouse gas emissions, and potential pathogen reductions.

Landfill Gas

In 2003, East Kentucky Power Cooperative (EKPC) opened the first landfill gas power plant in Kentucky. The plant makes electricity by collecting and burning methane gas in combustion engine-generators. Methane is a natural byproduct of the decomposition of organic waste and a powerful greenhouse gas. By burning methane, landfill gas plants not only supply renewable energy, they also prevent methane from entering the atmosphere. Today, EKPC operates five landfill gas power plants across the state. With a total generating capacity of 16 megawatts, the plants provide enough electricity to power about 8,000 homes.

A 2003 assessment of wastewater AD plants in Wisconsin concluded that the technology can be cost effective for plants treating at least one million gallons per day (Vik, 2003). According to the USDA, the long-term success of AD systems in the livestock industry has been more limited. In many cases, the AD systems failed, not because of technological shortcomings but because the owner was unwilling to continue with the necessary operation and maintenance. Nonetheless, renewed interest in AD technology over the past five years has led to an increase in the number of vendors marketing complete systems. The most cost effective designs are likely to be installed at larger animal feeding operations and directly use the biogas produced on site. Biogas systems are less complex and thus cheaper to install and operate compared to systems that generate electricity (USDA, 2007).

Woody Biomass

Kentucky has great potential for producing renewable energy from woody biomass (Figure 12). Wood energy sources might include woody residues from primary and secondary forest industries (such as bark, sawdust, slabs, trimming and edgings, etc.), residues from logging (tops, unmerchantable sections of stemwood), urban wood residues, woody energy plantations, and a portion of net forest growth that is not currently utilized.

Kentucky is ranked as one of the top five states in the production of industrial wood residues (1.59 million dry tons per year). However, most of these residues, primarily from sawmills, are already utilized as boiler fuel, horse bedding, landscape materials/mulch, charcoal, and other products. The National Biomass Partnership (NBP) estimates that 3.5 million dry tons per year of underutilized biomass is available beyond what is being produced by Kentucky forest industries. The majority comes from logging residues associated with current harvest levels (1.95 million tons), but the removal of unmerchantable trees and underbrush for fuel deduction thinnings (1.21 million tons) and the diversion of urban residues (0.34 million tons) would also play a role. The NBP believes that another 3.78 million dry tons per year could be realized by using 25 percent of the land not cropped or enrolled in the Conservation Reserve Program to grow short rotation woody crops like hybrid poplar or willow, assuming a nominal biomass yield of 4.5 dry tons per acre per year (NBP, 2007).

Maker's Mark Distillery

Maker's Mark Distillery is a straight Kentucky bourbon whisky maker that has had an annual average growth rate of 12 to 15 percent over the last 15 years. To allow for further growth and expansion, Maker's Mark had to solve the problem of disposal of its still byproducts (a water/grain mix that's left over after the alcohol is removed from the mash). Traditional disposal uses a Dry House which takes the raw (approximately 10 percent solids) still byproducts and evaporates the water to leave about 80-90 percent solids that can be sold as an animal feed called distiller's dried grains (DDG). Unfortunately, the burgeoning fuel ethanol industry has resulted in a glut of DDG. The oversupply of DDG plus the tremendous amount of energy consumed by a Dry House convinced Maker's Mark that they needed to find a new method to treat their still byproducts.

Maker's Mark chose a 'green' method of treatment. After three years of research, they chose a high-rate anaerobic system from Ecovation Inc. This system captures waste heat used to pre-heat lake water for the mashing process, produces a 42 percent solids animal feed, and most important, produces enough methane gas to replace up to 30 percent of the natural gas used by the plant. Any organics not converted to methane in the anaerobic digester are processed through an aerobic wastewater treatment plant, leaving water pure enough to return to the waters of the commonwealth.

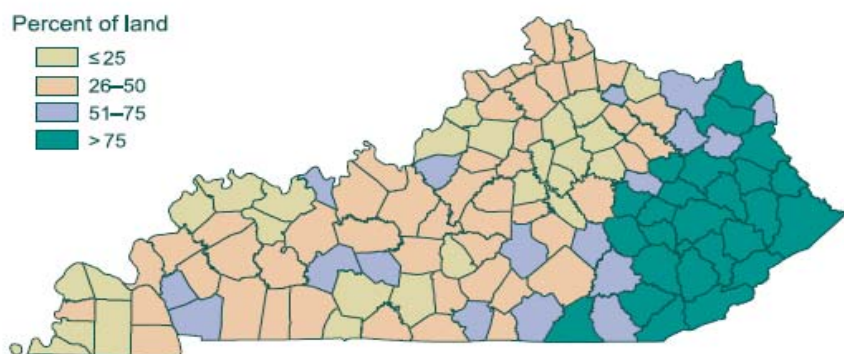


Figure 12: Forested Land Covers 12 million acres (47 percent) of Kentucky (Turner, 2008)

The net growth of merchantable trees could yield an additional 1.9 million dry tons of biomass potential annually. According to Kentucky's 2004 Forest Inventory and Analysis, Kentucky forests are annually growing more biomass than is being removed. The analysis concludes that approximately one billion board feet of sawtimber, equivalent to 1.9 million dry tons per year, is available from the net growth of merchantable trees (Turner, 2008). Net growth is defined as growth beyond what is removed either through harvesting or loss of forest acreage.

In total, approximately 9.18 million dry tons of biomass potentially could be annually harvested, recovered, or specifically grown for biomass fuel in Kentucky without diverting biomass from existing uses. Assuming a heating value of 8,000 Btu per dry pound, this resource could provide up to 147 trillion Btu of renewable energy potential each year; however, capitalizing on the entirety of this resource is unlikely, despite being technically feasible.

The utilization capacity will eventually be determined by the marketplace with pressure anticipated from carbon management and renewable energy policies at the state and/or federal level. Lacking additional economic analysis and recognizing that only a portion of this resource will be developed, it is assumed that Kentucky's forests will contribute 66.9 trillion Btu of energy in 2025. This is approximately two and a half times more biomass energy than what is being utilized today (EIA, 2008c).

An advantage to woody biomass material is that it can be used to produce a variety of end-use products such as fuels, chemicals and power. It can be burned directly or converted into combustible fuels using thermal and/or chemical processes (Badger et al., 2007). While woody biomass is generally more cost-effective when co-fired with fossil fuels, this approach introduces a number of material handling and material compatibility issues. A bigger concern for older plants is permitting. Many facilities currently operate under permits that were grandfathered in when environmental regulations were strengthened. Such permits often limit the types of fuels they are allowed to burn. As long as they continue to operate as dictated by the original permit, they are not required to upgrade the facility. This creates a possible disincentive for incremental changes

Failure to protect Kentucky's forests from over-harvesting and poor management practices will jeopardize one of the state's largest resources for renewable energy. The woody biomass identified in the National Biomass Partnership report comes from low value sources that are not in direct conflict with Kentucky's wood product industries. However, additional pressures from an emerging energy sector could easily create conflict between the two industries and harm the forest resource base. The use of these resources, in particular the net growth of merchantable trees, will require careful harvests to protect the forests. A renewed focus on forest management education and land-use policies will be necessary to ensure that Kentucky can provide a truly sustainable supply of woody biomass for all its needs.

even if the outcome is an improvement in overall emissions (Badger et al., 2007b).

It is important to note that the potential for cellulosic ethanol identified in *Strategy 3* does not include the 66.9 trillion Btu per year of woody biomass resources described above. Woody biomass could conceivably be used to produce either electricity or transportation fuel. The end use will be dictated by the market economics defined in part by material and land availability, consumer demand, emerging technologies, financial incentives and government policy. Utility companies will be more favorably inclined to policies that are positive and certain. The current federal Renewable Fuels Standard requires 36 billion gallons of renewable fuels to be used by 2022, of which 16 billion gallons must come from cellulosic resources (RFA, 2008).

Hydroelectric Power

In 2008, the Kentucky legislature authorized the Kentucky River Authority to promote private investment in the installation of hydroelectric generating units on all existing constructed and reconstructed Kentucky River dams under its jurisdiction (LRC, 2008).

The potential for new hydroelectric generation in Kentucky is likely to occur at sites that have an existing impoundment or minimally invasive run-of-river projects. Hydropower development is difficult because of competing uses for water, concerns for fish and wildlife, and the potential for impact by drought. In 1998, the Idaho National Laboratory (INL) conducted a resource assessment of the undeveloped hydropower potential in Kentucky. Forty-seven of the 51 sites assessed in the study already have some type of dam or impoundment, and 65 percent were considered small hydropower, less than 10 megawatts. The total undeveloped hydropower potential was 439 megawatts (INL, 1998).

Large hydro projects require very long lead times and large capital investments, and usually generate significant stakeholder opposition. Three new hydroelectric projects have been announced and two are in the early stages of development that utilize existing infrastructure. The projects range from five megawatts to 105 megawatts with a total generating capacity of 262 megawatts (Overland, 2008).

Assuming a quarter of the 701 megawatts identified in these two reports is developed and assuming a 40 percent capacity factor for hydro, Kentucky could replace 5.4 trillion Btu of fossil-based fuels. The additional capacity represents a 24 percent increase over the 2006 hydropower generation and would bring the state's total hydropower potential to 35.0 trillion Btu.

Hydropower

In 2006, Lock 7 Hydro Partners, LLC began renovating the dormant turbine-generators at Lock and Dam 7 on the Kentucky River near Harrodsburg, KY. Renamed the Mother Ann Lee Hydroelectric Station, the plant consists of three turbines with a total electricity generating capacity of more than two megawatts. The hydro plant is one of only a few dozen to be certified by the Low Impact Hydro Institute for minimizing its environmental impacts on fish, wildlife and other resources. Once fully renovated, Mother Ann Lee is expected to generate 8.3 million kilowatt-hours a year, which is roughly the amount of electricity consumed by 800 U.S. households in a year.

Renewable Energy Markets

Mechanisms for promoting renewable energy include voluntary and mandatory markets. Mandatory markets exist where policy decisions, such as state renewable portfolio standards,

dictate that electric service providers include a minimum amount of renewable energy in their electricity supply. To promote portfolio diversification, many states establish set-aside or “carve outs” for higher cost technologies. Without carve-outs, an RPS will generally exhaust low-cost technologies first before maturing other markets (Clean Energy Group, 2008).

Kentucky does not currently have a Renewable Portfolio Standard (RPS). The matter was formally reviewed in the PSC Case 2007-00477 in which the PSC advised that the structure of an RPS as well as the reliability and cost effectiveness of an energy portfolio containing increasing amounts of renewable energy should be reviewed and evaluated. (PSC, 2008b). In setting an RPS for Kentucky consideration must be given to both jurisdictional and non-jurisdictional energy service providers and how the RPS is applied to each.

Voluntary consumer decisions to purchase electricity supplied from renewable energy sources represent a powerful market support mechanism for renewable energy development. Beginning in the early 1990s, a small number of U.S. utilities began offering “green power” options to their customers. Green power represents renewable energy resources and technologies that provide the highest environmental benefit. Customers often buy green power for avoided environmental impacts and to support its greenhouse gas reduction benefits. Many Fortune 500 companies, local, state and federal governments, and a growing number of colleges and universities purchase green power to demonstrate their commitment to the environment and to lead by example (EPA, 2008c).

In Kentucky, all electric utilities regulated by the PSC offer green power to their utility customers. Green power is purchased in blocks of kilowatt-hours with price premiums ranging from 1.67 to 2.75 cents per kilowatt-hour. The 2006 average residential price for electricity in Kentucky was 7.02 cents per kilowatt-hour.

As an alternative to green power, or where green power is not available, individuals and organizations can support renewable energy development by purchasing Renewable Energy Certificates (RECs). A REC represents the property rights to the environmental, social, and other non-power qualities of one megawatt-hour of renewable electricity generation. A REC, and its associated attributes and benefits, can be sold separately from the underlying physical electricity associated with a renewable generation source (EPA, 2008d). RECs provide buyers flexibility in procuring green power across a diverse geographical area, but do not necessarily support local renewable energy projects.

Incentives

Recognizing the benefits of renewable energy, many state, local, utility and federal programs offer incentives to reduce up-front costs. The biggest incentives generally exist in states having a renewable portfolio standard.

Incentives based on installation and system costs are fairly common. These include rebates, tax credits, and tax exemptions. Although easy to implement, these types of incentives are often short-lived and offset a relatively small portion of the initial price.

Performance-based incentives are inherently more complex, but offer greater potential for reimbursement. With this approach, incentives are generally paid out over time based on system production. The incentive could be a direct per kilowatt-hour payment like that used for feed-in tariffs or an indirect payment such as the market value placed on a tradable REC. A feed-in tariff, also known as a renewable energy payment, is a premium rate that is guaranteed over a long-term contract for the generation of renewable energy. With tradable instruments like RECs, the market is left to determine the price.

Challenges to Renewable Energy Production

Financial

Renewable energy markets, until they mature, need predictable, long-term incentives and policy support to function in the near term. A significant barrier to the wide-spread adoption of renewable energy systems is that initial costs are high while the financial savings from avoided energy purchases are low.

Kentucky has not had a major driver to help encourage the use of renewable energy. Only recently were utility-scale, renewable energy facilities included in state tax incentive financing. In 2007, Kentucky passed the "Incentives for Energy Independence Act" which provides incentives for companies that construct, retrofit or upgrade a facility to generate electricity from renewable energy resources. To qualify, the renewable energy facility must generate at least one megawatt of power (50 kilowatts for solar) and incur a minimum capital investment of \$1 million (LRC, 2007).

Through 2008, state-wide incentives for homeowners and businesses to install renewable energy systems are limited to the federal tax credit for solar energy contained in the Energy Policy Act of 2005. The credit, recently extended through 2016, covers 30 percent of the cost of a solar PV or solar hot water system up to \$2,000. In 2009, the cap will be removed for PV systems only (TIAP, 2008).

Beginning in 2009, Kentucky will offer a tax credit up to \$500 for homeowners and up to \$1,000 for businesses to install renewable energy systems utilizing wind and solar energy. Relative to the required capital investment, the tax credits are too small to significantly move the market. In order to grow the renewable energy markets in Kentucky, the incentives need to be better aligned with cost-based rates.

Regulatory

Renewable energy, by its nature, is closely tied to the strategy of distributed generation – producing electricity near its point of use. Distributed generation (DG) can provide system-wide benefits in the form of a diversified fuel mix and ease the strain on utility transmission and distribution networks. Often cited impediments to successful development of distributed generation are (PSC, 2008):

- Historically low electricity prices.
- Redundant technical requirements that increase interconnection costs.
- Utility standby charges for backup power.
- Arbitrary electricity prices for systems outside of net metering policies.
- Lack of standard siting requirements.

Two key prerequisites for developing distributed generation projects include the availability of uniform interconnection standards and net metering rules. They are fundamental to the issue of access to the grid on a basis of economic cost.

Standard interconnection rules establish clear and uniform processes and technical requirements that apply to utilities within a state. These rules reduce uncertainty and prevent time delays that clean distributed generation systems can encounter when obtaining approval for electric grid

connection. States that modified interconnection rules focusing only on net-metered systems have found these changes were insufficient to encourage renewable DG. This is largely due to the small capacity limits on net-metered systems, which limits larger DG systems from accessing the grid for back-up power.

Kentucky does not have a state-wide interconnection standard although the matter is under review. The PSC initiated Case 2008-00169, in response to Senate Bill 83 of the 2008 Regular Session, to establish interconnection and net-metering guidelines for retail electric suppliers (PSC, 2008). In February 2008, the EPA completed a research project to assess existing state interconnection rules for their DG friendliness. The EPA deemed Kentucky's interconnection standards to be unfavorable (EPA, 2008e).

The federal government has provided some degree of guidance to states on interconnection policy. Federal Energy Regulatory Commission (FERC) Order 2006, adopted in May 2005, includes three levels of review of DG systems up to 20 megawatts in capacity. Although FERC's interconnection rules for small generators are unlikely to have much impact on distribution-level interconnection (which is generally governed by states), the commission has stated that it hopes states will adopt its rules – with necessary modifications – to promote a more unified interconnection policy around the United States (IREC, 2007).

Net metering is an important tariff issue for DG systems whereby a customer's electric meter can run both forward and backward in the same metering period and the customer is charged only for the net amount of power used. By definition, true net metering calls for the utility to value distributed power generation at the retail rate using one meter. It is a low-cost and easily administered means of promoting direct customer investment in renewable energy.

Kentucky requires net metering for solar, wind, biomass or biogas, and hydro-energy systems with a generating capacity less than 30 kilowatts. If the cumulative generating capacity of net-metered systems reaches one percent or less of a utility's single-hour peak load during the previous year, the PSC may limit the utility's obligation to offer net metering. Kentucky's net metering law allows for excess electricity to be "rolled over" as credit against future consumption, but credits are not transferable when service is discontinued.

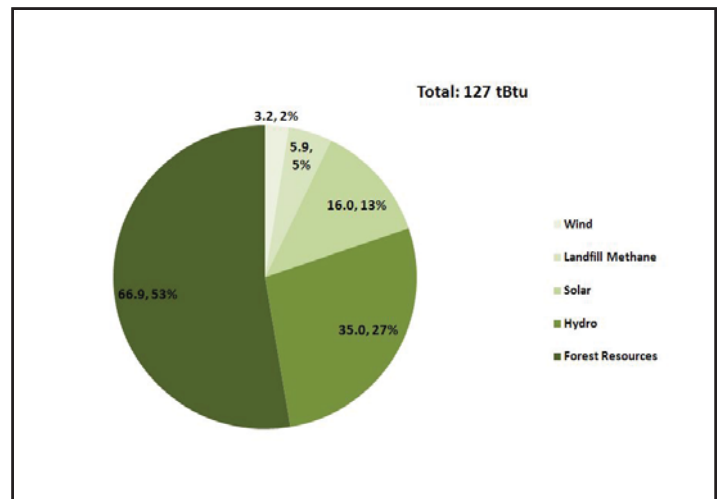


Figure 13: 2025 Renewable Energy Potential for Kentucky

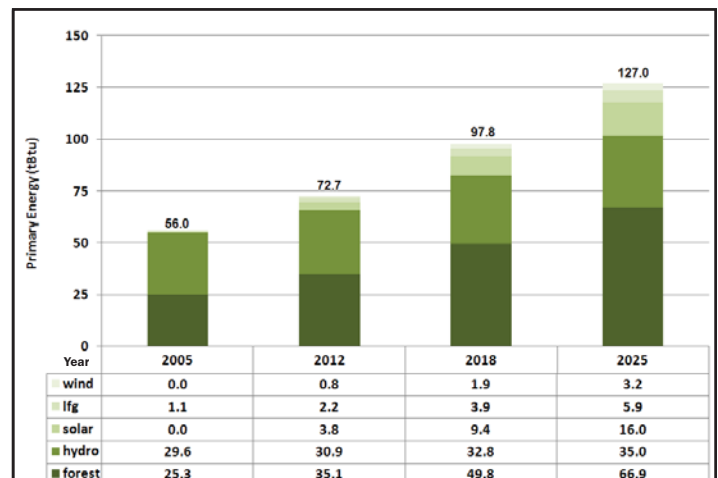


Figure 14: Renewable Energy Targets to 2025

¹ (2005 data: EIA, 2008c)

Fully Developing Kentucky's Renewable Energy Potential

Using forecast data from the EIA, the University of Kentucky report estimates the state's energy consumption in 2025 will be 2,815 trillion Btu. To achieve a 25 percent goal, Kentucky will need to provide 704 trillion Btu of energy in the form of energy efficiency, renewable energy and biofuels.

The resources identified in *Strategy 2* amount to 127 trillion Btu of renewable energy potential (Figure 13). Combined with 511 trillion Btu from energy efficiency (*Strategy 1*) and 66 trillion Btu from biofuels (*Strategy 3*), Kentucky can realistically achieve a Kentucky REPS goal of 25 percent by 2025.

Using a linear growth model, cumulative targets by resource for the years 2012, 2018 and 2025 are presented in Figure 14. Acknowledging that much of the future resource potential will be in the form of electricity, the units in Table 3 are presented in site-based megawatt-hours.

The 127 trillion Btu of renewable energy identified in *Strategy 2* does not include agricultural crops and crop residues applied toward biofuels production. Nor does it include renewable energy applications that were not addressed in the reference materials such as methane production from animal feeding operations and wastewater treatment facilities.

Clearly, more potential is available and will become available as technologies improve and the markets mature. If climate change legislation is passed and monetary penalties are tied to carbon emissions, many forms of renewable energy generation may become cost competitive and economically attractive.

The primary impediment toward the development of Kentucky's renewable energy potential today is economic viability. The energy potential can be realized using commercially available technologies which can be deployed quickly and scaled over time. Consequently, there is not a significant rationale to delay implementation of Kentucky's renewable resources if appropriate policies and incentives are created to ensure an adequate return on investment.

Developing appropriate policies and mechanisms to spur development of Kentucky's renewable energy sector will require further study. Currently, there are 26 states with mandatory renewable portfolio standards and another six with non-binding goals. To date, no broad, open-ended feed-in tariffs have

Table 3: Renewable Electricity Generation Targets to 2025

Renewable Resource	Thousand Megawatt-Hours (MWh)			
	Existing ¹	2012	2018	2025
Total Generation	3,052	4,509	6,694	9,244
Wind Energy	0	69	172	293
LFG / Biogas	88	191	347	528
Solar PV	0	272	679	1,154
Hydropower	2,592	2,708	2,883	3,087
Forest Biomass	372	1,268	2,613	4,182

¹ Existing generation from Table 2.

been created in the U.S., but revisions to RPS policies, necessary to meet increasingly aggressive environmental and economic development goals, have trended toward incorporating elements of feed-in tariffs (Rickerson et al., 2008).

Were Kentucky, on the other hand, to enact an incentive system that depends on tradable RECs, it must be well designed or projected revenues from Renewable Energy Credit (REC) sales will not be reliable enough or great enough to meet capital requirements. A well-designed market must include an adequate penalty for non-compliance to support sufficient REC prices and the requirement for long-term REC contracting. This type of structure provides predictable and sufficient REC revenue streams that better match the life-cycle of federal tax incentives and power purchase agreements (Overland, 2008).

ACHIEVING THE GOAL:

By 2025, Kentucky's renewable energy generation will triple to provide the equivalent of 1,000 megawatts of clean energy while continuing to produce safe, abundant, and affordable food, feed and fiber.

Near-Term Actions (1-3 years)

1. State government will lead by example by requiring new or substantially renovated public buildings to utilize renewable energy as a percentage of total energy consumption.
 - The High Performance Building Committee established in HB 2 (LRC, 2008) will establish renewable energy targets for 2012, 2018, and 2025 for new or substantially renovated buildings.
 - The requirements will escalate over time to reflect the state's renewable energy and energy efficiency goals.
2. The EEC will recommend policies and incentives necessary to achieve the state's renewable energy goal. The analysis will:
 - Analyze economic risks relating to carbon emissions and carbon mitigation strategies (*Strategy 6*).
 - As part of implementing the REPS for all suppliers of retail electric power, establish a timeframe for compliance and incremental percentages that will diversify the state's energy supply.
 - Evaluate the costs and benefits to ratepayers and taxpayers of achieving an RPS through different funding mechanisms (PBF, REC trading, feed-in tariff, tax incentives, etc.).
 - Recommend incentive programs necessary to stimulate the deployment of non-electric renewable resources (solar hot water, LFG, woody biomass, etc.).
 - Incorporate and suggest changes to existing state incentives for renewable energy systems (e.g., HB 1 and HB 2).
3. The PSC will develop state-wide interconnection guidelines for renewable energy systems.

4. Kentucky will review its policies and regulations to encourage the responsible use of woody biomass.
 - The Division for Air Quality will examine the rules for New Source Review with the EPA to reduce barriers for distributed generation projects that introduce new fuel sources, yet reduce total annual emissions (e.g., co-firing with biomass).
 - The Division of Forestry will review forestry and land-use policies and regulations to ensure that Kentucky has a sustainable supply of biomass for both its wood and power industries.

Mid-Term Actions (4-7 years)

1. Kentucky will review and make adjustments to its renewable energy policies and incentive programs as capacity grows.
2. Kentucky will amend its interconnection guidelines to allow renewable energy systems up to two megawatts.
3. Kentucky will implement forestry and land-use policies and/or regulations to ensure that Kentucky has a sustainable supply of biomass for its wood and power industries.

Long-Term Actions (>7 years)

1. Kentucky will annually align its renewable energy policies and incentive programs to be compatible with the state's renewable energy goal.

IMPLEMENTATION SCHEDULE

The rate of implementation of the renewable energy resources identified in *Strategy 2* will be greatly influenced by policy and incentives established at the state and federal level. Without intervention, significant movement in the renewable energy sector is unlikely. The recent trend in escalating energy prices will encourage greater adoption of renewable energy systems, but substantial growth in the market will require aggressive government policies that monetize the true costs of fossil energy consumption and send clear price signals to renewable energy markets.

ENVIRONMENTAL BENEFITS & LIMITATIONS

Electricity generation is the dominant industrial source of air emissions in the United States today. Fossil fuel-fired power plants are responsible for 67 percent of the nation's sulfur dioxide emissions, 23 percent of nitrogen oxide emissions, and 40 percent of man-made carbon dioxide emissions. These emissions can lead to smog, acid rain, and haze. In addition, these power plant emissions increase the risk of climate change. Renewable energy is receiving increased attention by environmental policymakers because renewable energy technologies have significantly lower emissions than traditional power generation technologies (EPA, 2008f).

Biomass power plants emit nitrogen oxides and a small amount of sulfur dioxide. The amounts emitted depend on the type of biomass that is burned and the type of generator used. Biomass contains much less sulfur and nitrogen than coal; therefore, when biomass is co-fired with coal, sulfur dioxide and nitrogen oxides emissions are lower than when coal is burned alone. Although the burning of biomass also produces carbon dioxide, the primary greenhouse gas, it is considered to be part of the natural carbon cycle of the earth. The plants take up carbon dioxide from the air while they are growing and then return it to the air when they are burned, thereby causing no net increase except for the energy used in agricultural production and gathering and preparation of the biomass as feedstock.

Burning landfill gas produces nitrogen oxides emissions as well as trace amounts of toxic materials. The amount of these emissions can vary widely, depending on the waste from which the landfill gas was created. The carbon dioxide released from burning LFG again is considered to be a part of the natural carbon cycle of the earth. Producing electricity from LFG avoids the need to use non-renewable resources to produce the same amount of electricity. In addition, burning LFG prevents the release of methane, a potent greenhouse gas, into the atmosphere.

The combustion of solid waste for energy raises similar concerns about hazardous air pollutants. Without proper emission control devices or sufficient presorting, the contents used to fuel MSW power plants, including any toxic materials, can be released into the air.

Air emissions from hydroelectric power are negligible because no fuels are burned. However, if a large amount of vegetation is growing along the riverbed when a new dam is built, it will decay in the lake that is created, causing an initial buildup and release of methane, a potent greenhouse gas.

Emissions associated with generating electricity from solar and wind technologies are negligible because no fuels are combusted.

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Strategy 3:

Sustainably Grow Kentucky's Production of Biofuels

GOAL By 2025, Kentucky will derive from biofuels 12 percent of its motor fuels demand (775 million gallons per year, which represents approximately 20 percent of Kentucky's current transportation fuels demand), while continuing to produce safe, abundant, and affordable food, feed and fiber.

The goal for *Strategy 3* is part of Kentucky's Alternative Transportation Fuels Standard (ATFS), which states that "by 2025, Kentucky can displace 60 percent of its reliance on foreign petroleum by utilizing fuels such as those derived from biomass and coal, plug-in hybrid vehicles, and compressed natural gas."

INTRODUCTION

The United States has become increasingly dependent on imported petroleum to meet its energy needs. About 70 percent of the petroleum consumed in the United States is by the transportation sector. A portfolio of domestic, more diverse feedstock for our nation's energy must be found to reduce this dependency and to secure our nation's and Kentucky's future energy supply. Biomass resources are a sustainable and, for the most part, environmentally benign source that can contribute significantly to a diverse energy portfolio.

Strategies 1, 2 and 3 support the Renewable and Efficiency Portfolio Standard (REPS) for Kentucky that states that "by 2025, Kentucky will derive at least 25 percent of its projected energy demand from energy efficiency, renewable energy and biofuels while continuing to produce safe, affordable and abundant food, feed and fiber."

Strategy 3, as a means to decrease our dependence on foreign oil, identifies actions to increase Kentucky's biofuels production capacity to 775 million gallons per year. This capacity represents approximately two percent of Kentucky's total projected 2025 energy demand and 12 percent of our 2025 liquid transportation fuel needs. To achieve this goal, Kentucky must continue to support biofuels made from traditional feedstocks as well as investigate and develop new feedstocks.

As an alternative to petroleum fuels, biofuels provide many benefits to the commonwealth:

- Improve balance of trade from reduced dependence on petroleum imports.
- Spur economic growth, particularly in rural America, from newly developing bio-industries.
- Reduce carbon emissions.
- Provide a more diverse energy portfolio and greater energy security.

Biofuels can be derived from a number of resources already found in Kentucky. Feedstock materials available in Kentucky include corn, soybeans, switchgrass, corn stover, other crop residues, animal fat and woody biomass. For purposes of this discussion, we have assigned all of Kentucky's woody biomass energy potential to *Strategy 2* to be developed as a resource for electricity production and carbon mitigation. However, the actual end use of woody biomass will be dictated by market economics, technology, government policy and incentives.

Kentucky's Biofuels Potential

Rising fuel prices, environmental concerns, pressures for security from foreign sources of oil and federal energy policy are creating a strong market for biofuels. In the United States, corn-based ethanol is currently the largest source of biofuel as a gasoline additive, and recent federal energy legislation mandates further growth of both corn-based and advanced biofuels from other sources. Lending promise to the industry is the increasing availability of ethanol and biodiesel at fuel pumps across the nation (Department of Agriculture, 2008). An analysis by the University of Kentucky estimates that Kentucky has an ethanol production potential of 668 million gallons per year (Table 4). Given that ethanol has approximately 70 percent of gasoline's energy content, Kentucky has a potential gasoline-equivalent production capacity of 468 million gallons per year, representing nearly 22 percent of the 2005 gasoline consumption. In 2005 Kentuckians consumed 2.1 billion gallons of gasoline.

Ethanol production could annually add up to \$355 million in value-added benefits to the state's economy and create about 1,800 new permanent jobs directly related to biofuels feedstock production. With this level of ethanol production \$3.1 million per year of new tax revenue would be generated, along with \$130 million dollars of value-added benefits in Kentucky through the construction of ethanol production plants (Colliver et al., 2008).

The state's 2025 potential biodiesel production capacity is estimated to be 107 million gallons (Table 4). Based on biodiesel's energy content (92 percent of petroleum diesel), the potential diesel-equivalent production capacity is about 98 million gallons of biodiesel, representing about 11 percent of 2005 diesel consumption. Kentucky's diesel consumption was 867 million gallons in 2005.

Recently, the U.S. Department of Energy (DOE) awarded a \$30 million grant to Ecofin LLC to help pay for a \$70 million cellulosic ethanol plant to be built in Springfield, Ky. The plant will produce ethanol and other value-added products using conventional feedstocks and cellulose, such as switch grass, corn cobs and corn stover. The company is also investigating the possibility of using algae systems to capture carbon dioxide and produce bio oil. The Kentucky Economic Development Finance Authority (KEDFA) has given preliminary approval for \$8 million in tax incentives to the company.

Table 4: Kentucky's Potential Biofuels Production Capacity *

Biofuel	Feedstock	Million Gal/yr	tBtus/yr
Ethanol	Corn	186	14.1
	Switchgrass**	361	27.4
	Corn Stover + Residues	121	9.2
	Ethanol Total:	668	50.7
Biodiesel	Vegetable Oil **	107	14.9
	Grand Total:	775	65.6

* Source: Colliver et al., 2008

** While the potential for switchgrass and algae as biofuels feedstock for Kentucky exists, the Colliver et al. 2008 report only calculated the potential for switchgrass and vegetable oil; many other candidate species are currently being investigated.

With an agricultural base of 85,000 farms and 13.8 million acres of total farmland, of which five million acres are annually harvested cropland, Kentucky is well-situated to meet these production goals (Kentucky Department of Agriculture, 2006).

Producing 775 million gallons of biofuels per year will require that a number of strategies and production techniques be put in place. Corn ethanol and biodiesel plants are already operating in the commonwealth. Kentucky has the capacity to support this level of biofuels production; however, economics, risk and sustainability will certainly influence the development of this resource.

Ethanol from Starch Crops

While corn is the primary feedstock for ethanol production (because of the extensive experience that exists in utilizing it and the high starch content of the plant), other crops are being investigated as potential feedstock crops, e.g., non-food crops, and will be discussed later in this strategy.

Higher demand for ethanol can increase corn prices, which can provide an incentive for farmers to raise additional corn. Kentucky's farmers are already responding to these higher prices. The University of Kentucky estimates that these factors and other developments can facilitate the production of an additional 44 million bushels of corn per year, resulting in a total of 186 million gallons of ethanol produced per year (Colliver et al., 2008). To achieve these ethanol production levels, Kentucky would need three to four new 50-million gallon production facilities.

While corn-based ethanol production has generated national debate over food versus fuel issues, future biofuels production can help alleviate many of the concerns in the debate. Non-food biofuel feedstock can be produced on less fertile lands that are only marginally suitable for food crops. Increased biofuel supplies can also help alleviate some of the demand pressures driving gasoline prices upward. The DOE and USDA estimate that United States gasoline consumption would be 7.2 billion gallons higher in 2008 if there were no biofuels available; the added fuel has had a moderating effect on U.S. gasoline prices, saving the average household about \$300 per year (DOE, 2008a).

Ethanol from Cellulose Plant Material

All green plants' primary building blocks are made of cellulose. This molecule is basically a long chain of smaller glucose molecules. These molecular chains are chemically broken with acids or enzymes, making the sugar molecules available for bacterial fermentation and ethanol production. While cellulosic ethanol production is technically feasible, the additional steps necessary to produce ethanol raise its cost of production to the point where it is not yet economically viable.

Switchgrass is frequently promoted as the candidate cellulose crop because it can be grown throughout

Commonwealth Agri-Energy--Ethanol

Agri-Energy is an ethanol production facility, built in Hopkinsville in 2004. This facility is cooperatively owned by the Kentucky Corn Grower's Association and the Hopkinsville Elevator Co-op. In 2008, the plant will use about 12 million bushels of corn per year to produce 33 million gallons ethanol, 107,000 tons of distillers dried grains (a production by-product used in livestock feed), 110,000 pounds of carbon dioxide for commercial use, and 3,000 ton of animal feed grade corn oil. The facility supports 32 direct jobs in the Hopkinsville community.

much of the United States, not to mention its potential high yield per acre and need for limited pesticide use. Other cellulose sources being investigated include residue from other crops, woody crops and municipal waste. Research should be continued to identify the ideal cellulose crop for Kentucky. However, for the purposes of this discussion, switchgrass will be used as the model crop species.

The potential for Kentucky lies in using some of the 2.15 million acres of land in non-alfalfa hay production (or "other-hay") for cellulose production. Depending upon market prices, it is estimated that approximately 550,000 acres of other-hay land could be converted to switchgrass production, providing 4.4 million tons of switchgrass (at approximately eight tons per acre). This level of production could produce 361 million gallons of ethanol per year from switchgrass (Colliver et al., 2008).

Crop residues, such as corn stover and wheat straw, could also be used to produce ethanol. Given Kentucky's corn and wheat production levels, and utilizing only 27 percent of total crop residue, 1.5 million tons per year of residue material could be provided, with an average ethanol yield of 80 gallons per ton. The potential from these resources would be about 121 million gallons of ethanol per year (Colliver et al., 2008).

Ethanol from Municipal Solid Waste

Municipal solid waste (MSW) is high in cellulose that could be utilized for ethanol production and has the added benefits of not competing for land or food crops. While many local governments struggle with solid waste disposal, utilizing these materials as a feedstock source could, at the same time, solve multiple problems. MSW suffers from some of the same challenges as other cellulose materials in that it must first be broken down to make the sugars available for ethanol production. Current research is focusing on improving conversion efficiencies, mitigating scale-up risks, mitigating risks associated with recycle stream contaminants, improving the co-product quality and marketability, and proving the capability of the plant to operate at near zero discharge. As an example, a commercial-scale MSW-to-ethanol facility is slated to begin construction in Pikeville in 2009, with a capacity to produce 20 million gallons of ethanol annually (WYMT News, 2008). A facility of this size is estimated to process approximately 1,500 tons of waste per day (Biomass Magazine, 2008).

Biodiesel from Oilseeds

Biodiesel is a renewable fuel produced from a wide range of vegetable oils and animal fats. Kentucky's current production of biodiesel comes from soybean oil and animal fats. These fats and oils are chemically reacted with an alcohol to produce chemical compounds known as fatty acid methyl esters. Pure biodiesel, or biodiesel blended with petroleum diesel,

Owensboro Grain Biodiesel

Owensboro Grain is a Kentucky-based company that started 101 years ago as a small grain merchant. In January 2008, the company opened a biodiesel plant in Owensboro, KY, with the capacity to produce 50 million gallons per year. The biodiesel plant is located adjacent to their vegetable oil refinery that processes soybeans from Kentucky and across the region. Annually the vegetable oil refinery produces 75 million gallons of soybean oil that provides a consistent-quality feedstock for biodiesel production. The biodiesel plant received funding assistance in the form of a grant from the Kentucky Agriculture Development Board and a low-interest loan from the Agriculture Finance Corp. The entire oil and biodiesel facility employs 160 individuals, adding nearly \$19 million to the local economy while generating approximately \$148 million in annual sales.

can be used to fuel diesel vehicles. Compared with petroleum diesel, using biodiesel in a conventional diesel engine substantially reduces emissions of unburned hydrocarbons, carbon monoxide, sulfates, particulate matter and other pollutants (DOE, 2008b).

The analysis by the University of Kentucky indicates that Kentucky has the potential to produce approximately 107 million gallons of biodiesel. To achieve this level of production, approximately 25 percent of Kentucky's soybean acreage and 25 percent of Kentucky's wheat acreage would be converted to canola/sunflower in double-cropped rotation (Colliver et al., 2008). This would provide the feedstock necessary to produce approximately 11 percent of Kentucky's 2005-level diesel consumption. To achieve these biodiesel production levels, Kentucky would need one to two new 50-million gallon per year production facilities.

Development of new cropping systems that significantly increase the availability of biodiesel feedstock is necessary if biofuels are to displace traditional petroleum-based distillates. Production of oilseed crops by Kentucky farmers will be determined by market economics, land availability, consumer demand, competing crop prices, and government policies and incentives.

An alternative to oilseeds for biodiesel is animal-derived products and recycled cooking oils and greases. While recycled materials require more pre-treatment than virgin oils, they are still an economical alternative at today's prices and help address a waste disposal problem.

Table 5: Comparison of Oil Yields for Various Crops

Crop	Oil Yield (gal/ac)
Corn	13
Soy	47
Safflower	83
Sunflower	102
Castor	150
Canola	171
Jatropha	192
Joboba	192
Algae	1600 - 8500

Source: Sun and Hobbs, 2008

Algae Biodiesel

Research is currently underway on the potential of algae as an oil source for biofuels. However, among the myriad algae species available, there has been little research to identify the best species for commercial utilization in Kentucky. The ideal species should be a freshwater species, abundant, and suited to Kentucky's environmental conditions. Diatoms are a common algae and are a likely feedstock candidate as they store their photosynthetic energy as oil (Steinitz-Kannan, 2008).

Diatoms, as an oil production organism, can help capture carbon dioxide from the atmosphere. Pairing diatom culture facilities with carbon-rich stack emissions from coal-fired power plants can provide dual benefits to society by removing carbon dioxide from power plant emissions, while generating a potential biofuels feedstock. Biodiesel fuels produced in this manner ultimately displace the release of carbon from non-renewable fossil fuels. More discussion on carbon capture and sequestration is presented as a part of *Strategy 6*.

Since diatoms demand nutrient-rich waters to grow, they also have the potential to "treat" wastewater effluent by removing nitrogen and phosphorus, helping dischargers comply with new nutrient permit limits. Pilot-scale studies still need to be conducted to refine methods for growing high oil-yielding diatoms using sewage or agricultural wastewater. Oil extraction techniques also need to be developed.

While diatoms have numerous physical characteristics that make them well-suited to large-scale culturing, it is important to note that they can be grown on marginally fertile land that does not compete with food-crop production. Oil yields of algae (Table 5) far surpass other candidate crops for biodiesel oil production, ranging from 1,600 to 8,500 gallons per acre (Sun and Hobbs, 2008).

Although Kentucky may not realize these upper yield levels due to limited sunlight intensities, algae production levels are still estimated to be on the order of 30 times the oil production of traditional food crops (Baum, 1994).

Implementation Challenges

While there is much promise in biofuels as a significant contributor to the commonwealth's energy needs, there remain many challenges. Some aspects of biofuels production and distribution still rely on leading-edge technology, and additional research is needed to develop these into commercially viable processes. Strategies for R&D to overcome barriers in the feedstock system include:

- Producing biomass feedstock in large enough quantities and with the desired properties that they can be more cost-effectively converted to useful fuels, power, or products.
- Reducing the cost of harvesting, transporting, and storing biomass material.
- Ensuring sustainable, environmentally sound agronomic practices.

But overcoming these barriers is feasible and highly likely.

As Kentucky sets its course towards energy security with this energy plan, the following challenges will need to be addressed for biofuels (DOE, 2007):

- **Geographic challenges**

Kentucky's farm profile is characterized by many small land owners, which presents challenges in economies of scale for production of biomass feedstock, such as use of lands marginally suitable for food crops, to meet increased demand and pricing; marketability of feedstock in a way that entices producers into the market; and economics of smaller-scale farms. These issues increase the importance of risk evaluation tools and methods to offset or reduce financial risk. This can be done.

- **Feedstock**

For Kentucky feedstock to significantly contribute to the biofuels energy picture, research breakthroughs are needed in a number of key areas, including:

- Identification of the ideal non-food feedstock crop for Kentucky (i.e., switchgrass or other candidate).
- Development of economically viable and scalable algae oil production and extraction technologies.
- Advances in plant science to improve the cost effectiveness of converting crops and residues to fuel, power and products.

Agronomic challenges related to feedstock production at the farm-scale include:

- Seasonality of feedstock crop vs. year-round biofuels industry; high initial costs for new crops, e.g. three-year delay to first harvest for switchgrass.
- Soil fertility and stability with continued harvesting of crop residue.
- The impact on Conservation and Grassland Reserve Programs due to increased feedstock demand.

In addition, R&D should focus on maintenance for perennial feedstock crops and advanced harvesting methods such as single pass harvesters and precision forest residue machinery. This will enable greater amounts of feedstock to be harvested at a lower cost. R&D is also required for the collection, storage and transportation of crop residue, as current infrastructure is not equipped to handle these processes.

- **Processing and Conversion**

Processing and conversion of feedstock to biofuels must be made more efficient. Science should strive to replicate processing systems found in nature. Greater efforts are needed to utilize byproducts of feedstock conversion and add value. Although improvements have been made in enzyme technology, significant improvements must still be made to further cut enzyme costs and increase the speed of reactions. Locating modular, decentralized processing and conversion facilities in proximity to both feedstock and retail markets will reduce transportation and distribution costs.

- **Infrastructure**

R&D is critical in assessing transportation and infrastructure of biofuels. Kentucky relies heavily on truck transport and storage at bulk plants, which can greatly increase transportation costs and increase the price of fuels. The most cost-effective method of transporting products in fluid form is through pipelines. But currently, biofuels cannot be transported through the same pipelines as petroleum fuels; this barrier must be overcome. The industry must develop partnerships for all legs of the distribution chain, including dedicated storage and blending facilities.

- **End-Use Markets**

To develop end-use markets, efforts are needed to evaluate and develop biofuels that are suitable for mass markets. Retail sales of biofuels, of course, also require fueling station outlets for the consumer. This will require a comprehensive education and marketing campaign to develop a customer base for alternative fuel vehicles. Continued research is also needed to identify possible new uses for co-products to keep the actual fuel costs as low as possible.

- **Education and Training**

Education of both decision-makers and the public on the benefits of biofuels is needed. Workforce education also will be required as Kentucky lacks the technical workforce to harvest, handle, and integrate biofuels feedstock into existing infrastructure.

These challenges are not insurmountable for Kentucky but will require acknowledgement, as well as commitment and support to address them. The need for a sustainable renewable fuel supply will drive the market economics and the determination to address these issues. Government's role, both at the state and federal level, is to provide incentives and to support research designed to remove these technical barriers.

ACHIEVING THE GOAL:

By 2025, Kentucky will derive from biofuels 12 percent of its motor fuels demand (775 million gallons per year, which represents approximately 20 percent of Kentucky's current transportation fuels demand), while continuing to produce safe, abundant, and affordable food, feed and fiber.

Underlying much of *Strategy 3* is a concerted effort to stimulate R&D to address technical or infrastructure challenges that have the potential to hinder the biofuels market. Many of these recommendations are adapted for Kentucky from the U.S. Department of Energy's "Roadmap for Bioenergy and Biobased Products in the United States."

To achieve our goal for biofuels, Kentucky will begin a statewide initiative to ensure that the needed infrastructure, human resources, research and development support, and policies are in place to enable meaningful and sustainable growth in biofuels.

Near-Term Actions (1-3 years)

1. Kentucky will invest in algae and other non-food crops as a feedstock for biodiesel.
 - The EEC, in partnership with Kentucky's research institutions, will evaluate high oil content crops best suited for biodiesel production in Kentucky and oil extraction techniques for algae. Priority will be given to crops that do not negatively influence food prices or availability.
 - Carbon capture initiatives will be integrated with the production of algae biodiesel (see *Strategy 6*).
 - The Center for Applied Energy Research will demonstrate a small-scale (estimated 50,000 gallons per year) pilot algae oil production plant and will convert the algae oil into biodiesel.
 - With a positive evaluation of high-oil content crops, the EEC, Kentucky's research institutions, the Governor's Office of Agricultural Policy, and the Kentucky Department of Agriculture will develop an aggressive strategy to introduce these crops on a commercial scale.
2. Kentucky will aggressively seek federal support for and invest in ventures that promote a market for ethanol from non-traditional feedstock, especially feedstocks that do not negatively affect food prices or availability.
 - Kentucky's research institutions will be encouraged to aggressively seek federal grants to address challenges in the production of cellulosic ethanol; the EEC will support federal grant opportunities with matching funds.

- The EEC and the Governor's Office of Agriculture Policy will work with Kentucky's Cooperative Extension Service to develop programs to instruct farmers and rural communities on how best to grow and support biomass feedstock production systems.
 - Establish a Biofuels Assistance Program that provides financial incentives to:
 - Kentucky producers to harvest, store and transport feedstock to biofuels facilities,
 - Kentucky's post-secondary institutions to conduct applied research to test best practices for cost-effective and environmentally sound harvesting, storage, and transporting of biofuels feedstocks.
 - Kentucky's research institutions will identify and develop feedstock crops that have improved yields, properties, and growth cycles consistent with Kentucky's needs. Evaluation should include the potential of cellulosic feedstock crops such as southern pine, willow, switchgrass, hybrid poplar, and miscanthus.
3. Establish an escalating renewable fuel standard (RFS) for the state vehicle fleet.
- The state will establish an initial renewable fuel standard of 10 percent, or 560,000 gallons (10 percent of an estimated 5.6 million gallons consumed annually by all state fleet vehicles) for E10 biofuel.
 - The state will require all eligible fueling stations under government contract to provide, at a minimum, E10 gasoline and B2 biodiesel by the year 2012.
4. Create incentives that encourage production, distribution, and demand for biofuels in Kentucky, in an environmentally sustainable manner.
- There will be a focus to fund initiatives that expand Kentucky's biofuels research capacity. This focus will include programs, such as "Bucks for Brains", which use state funds to match private donations, to attract and retain some of the nation's top researchers and scholars in biofuels.
 - The EEC will work with state and federal agricultural agencies to ensure proper incentives are in place to support best management practices for protection of the environment, while enhancing sustainability of feedstock production.
 - The Governor's Office of Agricultural Policy will provide financial and educational assistance to agricultural producers to enable them to be more competitive for federal energy efficiency grant and loan programs through the USDA, DOE and other agencies.
 - The Kentucky Agricultural Development Board (KADB) will provide grants and other funding opportunities for research, education, pilot projects, and farmer investments in the areas of on-farm energy efficiency, and commercial production of commodity-based renewable fuels. The KADB must receive its full share of the Master Settlement Agreement as referenced by the Kentucky statute (KRS 248.703) to support agri-energy initiatives in Kentucky.
 - The Kentucky Agricultural Finance Corporation will provide low-interest loans for on-farm infrastructure development and improvements as well as low-interest financing for the construction of commodity-based biofuels facilities.
 - Agricultural agencies will ensure that crop insurance programs provide adequate coverage for energy crops.
 - The EEC will determine how existing infrastructure can be best utilized to transport biofuels in bulk. Results will be used to support the deployment of new infrastructure as necessary.
 - Provide new incentives for fuel retailers to install biofuels (E10/E85) fueling infrastructure

with targets of 50 percent of all fueling stations by 2012 with E10 biofuel and 100 percent by 2025; 30 percent of all fueling stations with E85 by 2025. As a part of this initiative, Kentucky will establish and promote a Biofuels Trail, with designated E10/E85/Biodiesel fueling stations.

Mid-Term Actions (4-7 years)

1. A program of incentives will be created to reduce the risk of capitalizing and financing an additional three biofuels plants, including tax incentives to attract biofuels plants to Kentucky.
2. Kentucky research institutions will evaluate algae as a carbon capture mechanism for coal-fired power plants, supporting algae-based biodiesel production. There is also a need for low-cost methods to diversify feedstock if goals are to be met. Therefore, research will develop a diverse feedstock portfolio to ensure supply security and reduce the impact of price swings for a single crop.

Long-Term Actions (>7 years)

1. Kentucky research institutions will expand research on the production and utilization of promising non-traditional biomass feedstock (e.g., algae, canola, sunflower, cellulose, sweet sorghum, and short rotation woody crops) for biofuels.

IMPLEMENTATION SCHEDULE

The biofuels energy potential of 65.6 trillion Btus equates to 775 million gallons of transportation fuel (Figure 15). To capture this potential, focused research and development are essential and need to be coupled with incentives that drive the commercialization of emerging technologies and processes. House Bill 1 contains incentives to increase the production and sale of alternative transportation fuels, such as ethanol and biodiesel. Eligible projects include alternative fuel facilities that are carbon-capture ready and use biomass resources as the primary feedstock, with a minimum capital investment of \$25 million. Tax incentives are available for up to 25 years, up to a maximum of 50 percent of the capital investment.

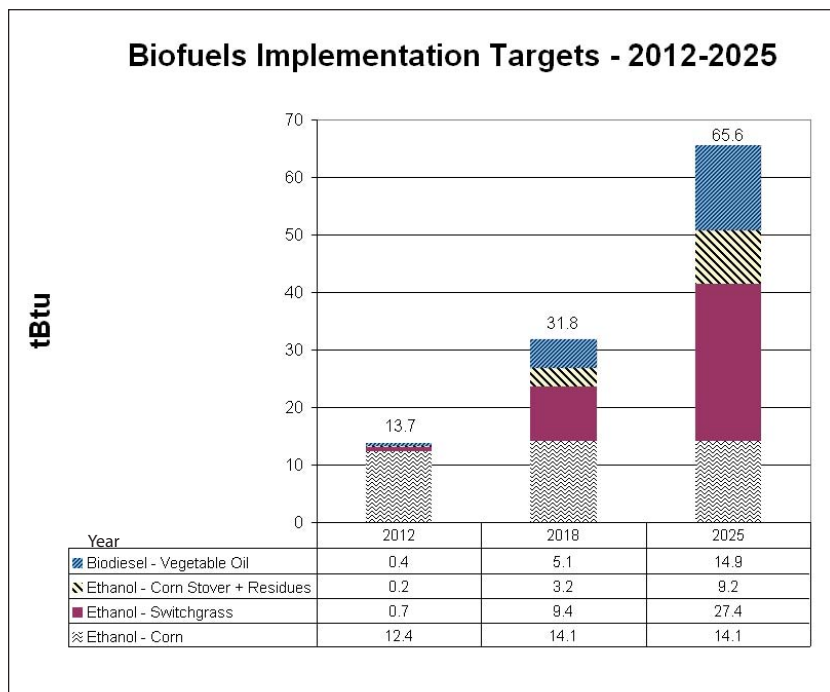


Figure 15: Biofuels Implementation Targets - 2012-2025

Kentucky's research institutions must collaborate with industry and the federal government to develop opportunities that benefit the commonwealth. The Ecofin LLC partnership with the University of Kentucky, U.S. Department of Energy and the commonwealth provides an excellent model. Additionally, Kentucky's Cooperative Extension Service and agricultural agencies must be involved and fully integrated to help farmers and rural communities develop new opportunities and learn how to grow new non-traditional energy crops.

As can be seen in Figure 10 in *Strategy 1*, biofuel is just one component to Kentucky's energy future. For biofuels to reach the goal stated in this strategy there will be a start-up period as market transformations occur. For more leading-edge technologies, such as cellulosic ethanol and oil extraction from algae for biodiesel, the initial growth curve will be delayed. The production targets presented in Figure 15 consider these start-up challenges and have been based on production trajectories in the mandated renewable fuel standards of the Energy Independence and Security Act of 2007 (RFA, 2008).

If current energy usage is projected to reach 2,815 trillion Btu by 2025, and given production capabilities in Kentucky, biofuels can help reduce our dependence on traditional energy sources by 65.6 trillion Btu. Figure 15 shows the projected contribution of biofuels to the energy efficiency and renewable energy goal as 13.7 trillion Btu by 2012, 31.8 trillion Btu by 2018, and 65.6 trillion Btu by 2025.

ENVIRONMENTAL BENEFITS & LIMITATIONS

Biofuels provide an opportunity to reduce transportation-related greenhouse gas emissions. By burning a renewable energy source, tail-pipe emissions represent no net gain in atmospheric carbon dioxide. In 2005, transportation-related carbon dioxide emissions for Kentucky were 33.5 million metric tons and are projected to reach 43.4 metric tons by 2025 (EIA, 2008). Even taking into account feedstock production, processing, and distribution of biofuels, ethanol provides substantial reductions in overall carbon dioxide contributions versus conventional petroleum-based fuels.

Since every fuel is used and produced differently and requires different energy inputs to produce, the associated levels of greenhouse gas emissions with a particular biofuel will vary accordingly (e.g., coal, natural gas, biomass) (Figure 16). Corn ethanol, for example, has the potential to reduce greenhouse gas emissions by as

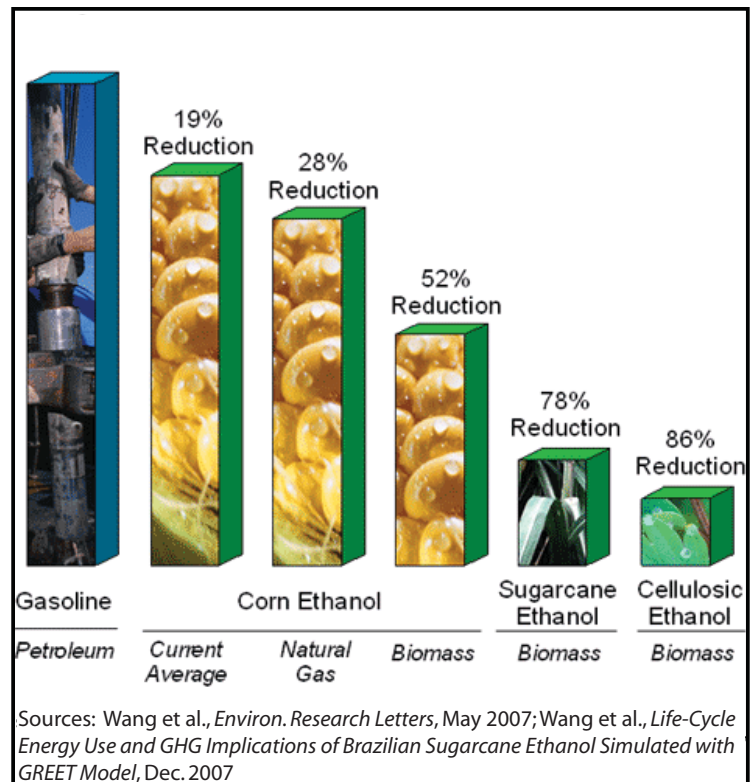


Figure 16: Greenhouse Gas Emissions by Transportation Fuel and Type of Energy Used in Processing

much as 19 percent over petroleum-based fuels, when evaluated on a full fuel-cycle basis, while biofuels made from cellulosic feedstock, such as switchgrass, woody biomass, or agricultural residues such as corn stover, have the potential to reduce greenhouse gas emissions by as much as 86 percent, when compared to gasoline (DOE, 2008c). Biodiesel can reduce carbon dioxide emissions by 78 percent (National Renewable Energy Laboratory, 1998). Implementing *Strategy 3* can reduce carbon dioxide emissions by 3.2 million metric tons.

In addition to greenhouse gases, biofuels can help reduce other air pollutants associated with petroleum-based transportation fuels. Approximately 257,519 tons of sulfur dioxide and 148,433 tons of fine particulate matter (EPA, 2008b and 2008c) were attributed to road vehicles in 2002. Because of the low-sulfur content of biofuels (often one percent that of coal), sulfur oxides and particulate matter will be reduced through their use as fossil fuel replacements (Hughes, 2008; EPA, 2008a). Another benefit is an expected 75-85 percent reduction of polycyclic aromatic hydrocarbons, which have been linked to cancer (Kentucky Division for Air Quality, 2008). The use of biodiesel will be particularly beneficial in areas that do not meet national ambient air quality standards, because they emit significantly fewer contributors to non-attainment for particulates and ozone.

As previously stated, biofuels reduce demand for fossil fuel production when evaluated on a fuel-cycle basis; i.e., the energy input-to-output ratio is lower for ethanol than for petroleum-based fuels, even when considering energy inputs from feedstock production, processing and distribution. Ethanol produced from corn produces a net energy return of 1.34 (energy input to output), meaning that it yields 34 percent more energy than it takes to produce it, with a net energy value of 41,105 Btu per gallon (Department of Agriculture, 2002).

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Strategy 4:

Develop a Coal-to-Liquids (CTL) Industry in Kentucky to Replace Petroleum-Based Liquids

GOAL Kentucky will develop a CTL industry that will use 50 million tons of coal per year to produce four billion gallons of liquid fuel per year by 2025.

The goal for Strategy 4 is part of Kentucky's Alternative Transportation Fuels Standard (ATFS), which states that Kentucky can displace 60 percent of its reliance on foreign petroleum by utilizing fuels such as those derived from biomass and coal, plug-in hybrid vehicles, and compressed natural gas.

INTRODUCTION

With its vast coal resources, proven support from elected officials, and dedicated research and development program, Kentucky is uniquely positioned to develop a coal-to-liquid fuels industry that can serve as an engine for economic growth, while helping to reduce our dependence on foreign oil.

Transportation in Kentucky, like transportation in the rest of the United States, is primarily dependent on liquid fuels, and most of these fuels are derived from petroleum. Other products such as lubricants, liquid propane gas, and chemicals for the plastics industry are also made from crude oil, but by far the largest percentage is processed into liquid transportation fuels. Any analysis that concludes that an alternative to petroleum-based fuels is economically viable is equally valid for other products made from crude oil.

The price of crude oil has about doubled in the past year (Energy Information Administration, 2008). While price increases of this nature have happened in the past, crude prices have always come back down after a peak. Is what is happening now a similar spike which will subside, or is it likely that oil prices will remain high indefinitely? Some analysts point to such influences as speculation and fear of supply disruptions as feeding high crude oil prices, and predict that crude oil prices will once again retreat (Williams, 2007). While speculative and emotional factors may be influencing current prices, the overall market situation indicates that high crude oil prices are here to stay.

Peak Oil

The term "peak oil" is frequently seen in articles about energy supply, and is frequently blamed for increasing crude oil prices. In simplest terms, peak oil is the point at which world-wide oil production will peak, or has already peaked, depending on who is doing the calculation (Deffeyes, 2003). Peak oil is reached when the rate of discovery and production from new fields plus production from existing fields declines because there are not enough new fields being discovered and exploited to compensate for the decline in production from existing wells that are currently being depleted. Some experts such as Houston-based energy analyst Martin Simmons also make the argument that Saudi Arabia (and in some cases, other countries) may be overstating their reserves and that the problem of declining oil reserves is more imminent and desperate than we realize.

Others believe there are vast reserves of oil available to be recovered. The problem is not the amount of oil, but rather the amount of oil available that can be easily (and relatively inexpensively) extracted and processed. If the trillions of barrels of oil equivalent available in oil shales and tar

sands are accounted for, there is no shortage of oil (DOE, 2004). The cost of recovering this oil, or oil from deep ocean deposits or other remote, harsh extraction environments like the Arctic, is much higher than traditional oil extraction. Furthermore, the number of refineries that can process these non-traditional oils is not sufficient to supply world demand for liquid fuels.

The cost of oil extraction, which for years was constantly declining because of improved extraction techniques and productivity improvements, is now on the upswing with no reversal of the trend in sight.

Inelastic Demand

A second indication that high crude oil prices are here to stay is that the overall demand for oil is relatively inelastic; in other words, people will pay the price for the fuel, seemingly no matter how high the price per barrel goes. As stated above, the supply of inexpensive oil is dwindling. Overall demand for oil, though, is increasing worldwide. For instance, consumption in developing nations in Asia, the Middle East, and Latin America is expected to rise 3.7 percent per year between 2008 and 2013, more than offsetting a slight decline in demand in developed nations (International Energy Agency, 2008). So even if high oil prices do depress demand in the short run, in the long run, demand will continue to trend upward.

Availability of Substitute Fuels

A third factor that will tend to support continued high oil prices is the lack of available, acceptable substitutes for petroleum-based fuels. There have been other oil price spikes in the past (for instance, in the early 1980s), and other times when adequate supplies of oil have been unavailable (World War II and the OPEC oil embargo in the 1970s) and have created activity in pursuing alternate sources of liquid fuels, primarily from coal. The threat to demand for petroleum that coal presented has always helped push crude oil prices back to a level where coal fuels could not compete economically, and governments and private industries that had initiated coal fuels projects ceased supporting those efforts.

One notable example where pursuit of a substitute source of transportation fuels did not succumb to retreating oil prices was in South Africa. Because of their policy of apartheid (which triggered numerous calls for international trade boycotts of the country) and their lack of domestic oil reserves, South Africa made the strategic decision to develop their own internal coal-to-liquids industry to ensure that they would not be hostage to imported oil for their liquid fuels. SASOL, the name for what started as the South Africa Coal Oil and Gas Corporation, started producing automotive fuel in 1955 and now produces about 40 percent of South Africa's liquid fuel demands

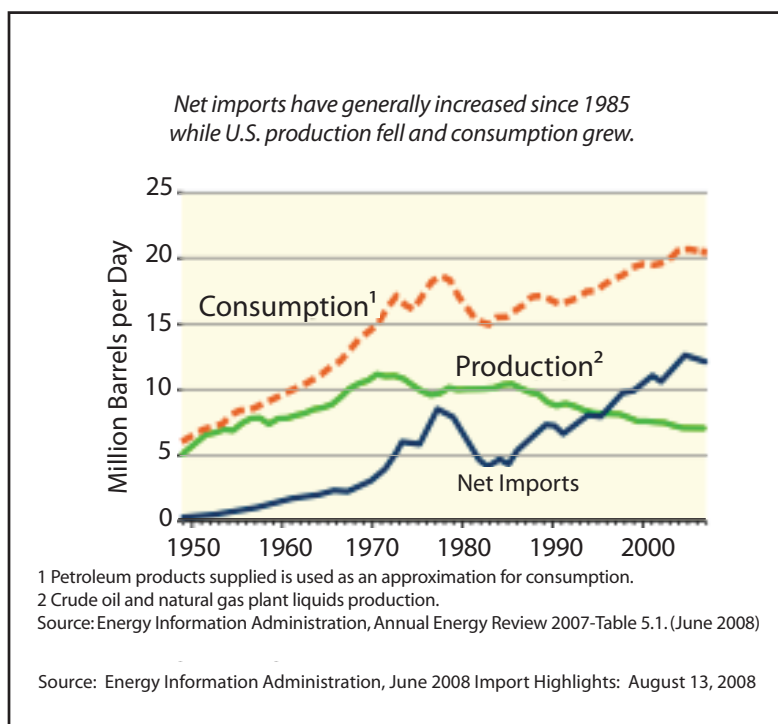


Figure 17: Consumption, Production and Import Trends for Petroleum (1950-2007)

from coal. Because of skyrocketing crude oil prices, SASOL intends to build a fourth CTL facility producing 80,000 barrels per day at an estimated cost of \$5-\$7 billion. In the last year profits at SASOL have risen 20 percent, and the share price of the company has more than tripled in the last three years (Schutze, 2008).

Impediments to Developing a Coal-to-Liquid Fuel Industry

In a market economy, availability of substitutes tends to keep the price of more or less interchangeable commodities on a par with each other, or at least at a stable ratio. So why is demand not shifting from fuels made from crude oil to liquid fuels made from coal?

There are three primary reasons. The first two are ones that have tended to stifle the industry before: Uncertainty over whether or not oil prices will remain high enough to make CTL facilities economically viable, and the high cost (in both dollars and time) of building the plants. The third reason is a new one which has begun to influence the development of CTL within the last ten years: carbon footprint.

Facility planners and the financial institutions that underwrite their projects do not use spot prices of oil as the basis for predicting the economic feasibility of CTL projects; they use predictive formulae. Until recently their predictions have not supported CTL plant development, but the number of projects now being considered both in the United States and worldwide indicate that those predictions are changing and should no longer present an impediment to CTL development. Numerous studies predict CTL projects will be profitable when crude oil is above \$50 - \$60 per barrel (Dapice, 2004; Schmetz, 2005; Bartis, 2007; Berg, 2007). There is no reason to believe that long-term prices of crude oil will drop and remain below that level.

High cost is still a factor due to congestion in the equipment manufacturing and construction sectors and escalating prices for construction materials. In 2006, the International Energy Agency (IEA) estimated capital costs of a one billion gallon per year CTL plant would be about \$5 billion; however, more recent estimates have been up to 30 percent higher (Taylor, 2007; Zhihong, 2007; Schutze, 2008). All major industrial and manufacturing enterprises are facing the same cost escalations and time delays.

There are numerous steps that can be taken to improve the borrowing climate for the debt financed portion of a CTL project. Some of these measures include:

- A state guarantee to purchase some or all of the off-take from a facility, with or without a price floor to help ensure profitability of the plant.
- Cost-control of the facility's raw material through long-term guaranteed contracts with suppliers.
- Guarantees regarding timing of the permitting process.
- Assistance with direct payment for some of the preliminary design requirements. For example, a rule of thumb is that the cost of the front-end engineering design (FEED) is about one percent of the project cost, so on a \$7 billion project the FEED would cost about \$70 million. The state could help defray that cost.
- Project cost share, possibly awarded competitively to the most attractive projects.
- Investment tax credits.
- Statutory exemption from standard rules that grant a given electric utility a monopoly on providing retail electricity in a certain geographic area (e.g., allow a gasification project to "wheel" any electricity generated from waste heat directly to a user at rates more favorable than the gasification project would get from the local utility).

- Provision of bond funding, or bond guarantees.
- Regulatory changes to ease right-of-way acquisition through eminent domain actions.
- Preferential funding for infrastructure requirements (such as local road improvements) that will facilitate operations at the proposed plant site.

Numerous studies have been done that attempt to rank order options such as those listed above for their ultimate impact on a project. For instance, in a 2007 study, the U.S. DOE analyzed three of these possible actions: Fischer Tropsch (F – T) subsidies, loan guarantees, and investment tax credits, and found that loan guarantees had the greatest impact of the three, with F – T subsidies falling in the middle. As expected given the impact of risk on the cost of debt financing, that rank order (loan guarantees, F – T subsidies, investment tax credits) is also the order of possible financial loss for the state. However, in addition to actual financial assistance, a strongly supportive environment provided by a state also has an appreciable positive impact on the financing environment.

Given the limitations on available capital that Kentucky faces as a relatively small state and the dollar size of the CTL industry that is envisioned, viable options for Kentucky would include: a guarantee of off-take purchase assistance with a long-term coal contract from a supplier; permitting; investment tax credits; regulatory exemption to allow CTL facilities to “wheel” power; eased right-of-way acquisition; and preference on infrastructure project funding.

It is the third issue, carbon footprint, that provides additional uncertainty regarding development of a CTL fuels industry. Unless some form of carbon management is included in the facility design, it is estimated that a CTL fuel plant will approximately double the amount of carbon dioxide emitted by a petroleum-based refinery, per unit of output (Adam, 2008; Natural Resources Defense Council, 2007).

One of the most promising carbon dioxide management techniques includes capture, compression, and underground sequestration (CCS). This is addressed in detail in *Strategy 6*. But even CCS has serious obstacles to successful large-scale deployment. Any extensive CCS network will increase the cost (estimates range from between 50 percent and over 100 percent) of existing coal-fired electricity production (DOE, 2007; Klara, 2007). There are also serious legal obstacles to large-scale CCS such as the difficulty of obtaining right-of-ways for required pipelines and questions regarding who owns the pore space that the carbon dioxide would be injected into and who would be liable for accidental discharges or leakage at injection sites.

Potential Adverse Impacts of Developing a CTL Industry

If the impediments to developing a CTL fuels industry are overcome, there are other unintended consequences that require mitigation. In recent years the coal industry has enjoyed substantial growth. Starting a new industry based on coal will, in the short run, result in tighter supplies and higher prices. This in turn will raise the cost of electricity generation as well as the cost of industrial and commercial activities which depend on steam generated by burning coal. A CTL industry will also compete with other industries for limited resources such as rail transport and water. The environmental and societal costs traditionally associated with coal mining will increase with increased mining if steps are not taken to minimize their impacts.

Economic Conclusions

Based on the above, it is legitimate to conclude that the current and future market for crude oil makes CTL fuels production economically viable, as long as steps are taken to ensure that carbon management legislation does not punish the manufacture of CTL fuels excessively. So the question is: Does Kentucky want to actively support development of a CTL fuels industry, and if so, what steps must be taken to ensure its success?

Assessment

Kentucky is a "coal state". Coal supports Kentucky's economy in three ways: First is the benefit in direct and indirect employment in the coal industry and the economic and tax revenues generated by the industry. Second, over 90 percent of Kentucky's electricity is generated using coal. Coal-fired power plants provide the cheapest electricity generation available; therefore each Kentucky citizen receives an economic benefit from having one of the lowest electricity costs in the nation. Third, those same low electricity rates make Kentucky attractive to electricity-intensive industries like steel, aluminum, and automotive. Employment and revenues in those and many other industries are a direct result of low-cost electricity.

Any kind of tax on carbon emissions or any cap-and-trade program requiring reductions in carbon emissions will raise the price of coal-fired electricity disproportionately compared to other forms such as nuclear, wind, or hydroelectric. To illustrate, if the cost of coal-fired generation doubles while other sources stay the same, then a state where 50 percent of the electricity is generated using coal will, on the average, have a 50 percent increase in electricity costs. In a state like Kentucky where practically all of the electricity is provided by coal, rates could almost double. This would place an immediate burden on Kentucky consumers and eliminate one of Kentucky's big advantages in attracting new industry or keeping industry already located here, and in the long run stifle demand for coal, putting downward pressure on coal prices and reducing the amount mined.

Because of the fundamental technology used to make CTL fuels, CCS costs would constitute a considerably smaller percentage of overall operating costs than they would with electricity generation (see Berg, DOE, and Oakley et al., 2007). These analyses demonstrate that even with the expected increase in costs of adding CCS to a CTL fuels facility, such a facility will still be economically viable when crude petroleum costs are in the \$50-\$60 per barrel range.

Developing a CTL fuels industry in Kentucky not only provides a whole new high technology industry potentially providing thousands of high paying jobs, it also supports the coal industry by providing a market for Kentucky coal. In 2006 Kentucky produced approximately 126 million tons of coal. If all of that coal were made into liquid fuels, it would make approximately 10 billion gallons of diesel fuel. In 2006 demand for diesel fuel in the United States was over 40 billion gallons. In other words, developing a CTL fuels industry would boost Kentucky's economy by providing a use for coal other than electricity generation and by providing jobs in Kentucky to produce the coal-based liquids.

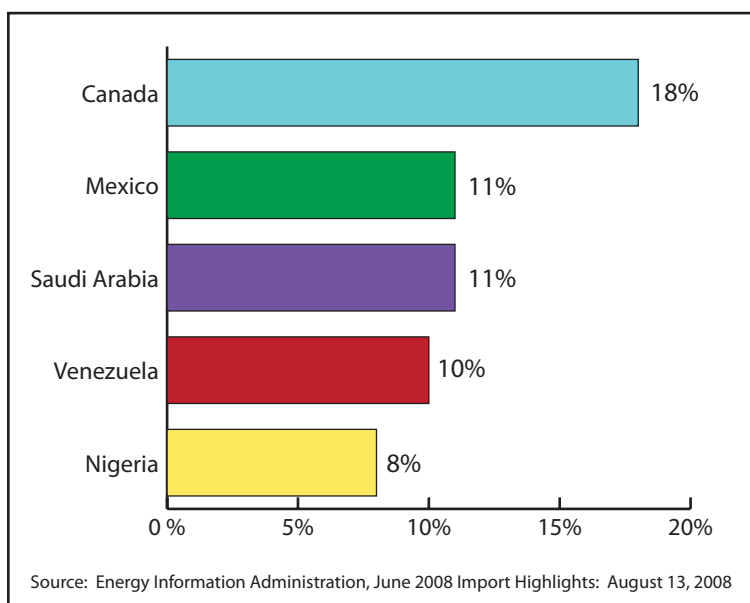
The direct impact on Kentucky's economy of a strong CTL program will be substantial. Estimates of construction jobs, permanent jobs and projected tax revenues indicate that a plan as aggressive as the one proposed for Kentucky would provide a huge economic stimulus.

One of the more detailed analyses available for a sizeable CTL project has been presented by

Rickard, 2006. In that paper Rickard uses the Minnesota Implan Group's Implan 2.0 economic impact assessment software system to predict the total economic and fiscal impacts of the proposed Bull Mountain energy project in Musselshell County, Montana. That study predicts that an 11,000 barrel-per-day project would create approximately 3,950 jobs during the construction phase, and that operation of the facility would create approximately 3,575 direct and indirect jobs. Rickard's study further predicts that labor income from the facility would be approximately \$233 million per year, and that the facility would generate about \$20 million in state, county, and city tax revenue per year. Extrapolation to Kentucky's proposed 260,000 barrel-per-day plan would suggest substantial impact on job growth and economic benefits. Rickard's analysis seems quite optimistic, and more conservative estimates (CAER, 2007) would place direct employment around 3,500.

But there are other benefits that would accrue not only to Kentucky but also to the nation as a whole. By developing a CTL fuels industry, Kentucky can position itself as a national leader in two essential areas. First, national security will be enhanced. Currently, foreign countries provide about 60 percent of the crude oil consumed by the United States. The top 15 countries that supply that crude oil include Nigeria (#5), Angola (#7), Algeria (#8), Columbia (#11), and Ecuador (#12), all of which suffer from periodic political turmoil and all of which are subject to supply disruptions. The top 15 exporters to the United States also include Venezuela (#4) whose leader is openly hostile to America (EIA, 2008). Finally, while Iran does not export oil to the United States, it is the fourth largest oil producer in the world (EIA, 2007). Since oil supplies are tight worldwide, disruption in any of the major oil exporting countries would cause shortages and price spikes that would eventually have a negative ripple effect on the United States. By developing a robust CTL fuels industry, Kentucky would take a large step toward helping ensure America's energy independence and security.

Secondly, a strong CTL fuels industry would benefit the United States as a new industry in and of itself, but more importantly, would provide a dependable supply of liquid fuels at a predictable price and thus help make U.S. manufacturing more competitive.



The potential benefits described above overwhelmingly support development of a CTL fuels industry in Kentucky.

Kentucky is promoting CTL development. Through fiscal year 2009, the EEC has funded initial site assessments and feasibility studies at seven properties across the state. The EEC has also developed a "site bank" of 41 properties that have been initially screened for CTL development potential. These sites were nominated by local officials seeking to promote CTL development in their area.

The state, through the EEC, has also devoted significant grant funding for construction of a demonstration-scale F - T refinery at the CAER, and has also funded critical research needed to develop F - T catalysts.

Figure 18: Top Suppliers of Crude Oil and Petroleum Products to the United States (2007)

ACHIEVING THE GOAL

Kentucky will develop a CTL industry that will use 50 million tons of coal per year to produce four billion gallons of liquid fuel per year by 2025.

This would ensure that there is a market for Kentucky's coal, provide a source of high-technology, high-paying jobs for Kentucky citizens, and put Kentucky in a leadership role in reducing the United States' dependence on imported oil.

In 2006 Kentucky used annually approximately 2.26 billion gallons of gasoline, approximately 1.3 billion gallons of diesel and approximately 298 million gallons of jet fuel, for a total of almost four billion gallons of liquid fuels. It is assumed here that the producers of the liquid fuels will determine the correct mix of exact products to manufacture. Therefore, for planning purposes, the generic term 'CTL fuels' will be used without identifying or differentiating between the exact products. Also for planning purposes, it is assumed that the transportation fuels usage in 2025 will be the same as in 2006 (approximately four billion gallons). While in normal circumstances growth would be expected, the impact of federal fuel economy legislation and the move to plug-in hybrid electric automobiles will absorb some of the growth in liquid fuels demand.

Near-Term Actions (1-3 years)

1. Work with vocational training institutes in Kentucky to ensure that trained personnel are available to work in the coal industry required for CTL industry development. For two CTL fuels facilities to come on line in 2013, trained personnel must be available to meet possible production levels of 138 million tons per year in 2013, 150 million tons per year in 2014, 163 million tons per year in 2015, and 175 million tons per year in 2016. While it is expected that federal carbon management legislation will reduce these levels in later years (due to reduced exports to other states), it would be an unacceptable risk to the planned CTL and coal-to-gas (CTG) industries not to have an adequate supply of trained personnel. To achieve the required employment levels, increased training capability must be available within the next three years.
2. The all-time high production level that the Kentucky coal industry achieved was 179.4 million tons in 1990. Since this level has been reached in the past, it should be achievable in the near term as long as trained personnel are available for the mines. In order for the electric generating industry in Kentucky to transition from coal, the first four CTL plants (a total of 25 million tons of coal per year) should be fed with existing production capacity; i.e., production above the 125 million ton level that was achieved during 2006. In the near term, Kentucky must evaluate its current coal mining capabilities and ensure that it can readily reach 175 million tons per year as it has in the past, if in fact that should prove necessary.
3. Kentucky already has economic incentives in place to encourage the CTL industry. However, state legislation will be necessary to remove the risk barriers which may prevent CTL development. There are undeniable advantages to being a leading state supporting the industry; companies that pursue production of CTL fuels will be more likely to locate in Kentucky if the state has an advantage over other states in available support. By acting quickly and decisively, Kentucky can ensure that CTL facilities are built here.

Mid-Term Actions (3-7 years)

1. Bring on line two new 500 million gallon-per-year (approximately 35,000 barrels per day) CTL facilities in both 2013 and 2014.
2. Prepare for a substantial expansion of the Kentucky coal mining industry above recent production rates (126 million tons per year).

Long-Term Actions (>7 years)

1. Bring on line two additional 438 million gallon-per-year CTL fuel facilities by 2018 and two more by 2025.

ENVIRONMENTAL BENEFITS AND LIMITATIONS

According to the Energy Information Administration (EIA), in 2006 Kentucky used approximately 42 million tons of coal to produce about 91,000 megawatt-hours of electricity from approximately 15,500 megawatts of electricity capacity. Without changes to Kentucky's electricity generation mix, those numbers are expected to grow to 59 million tons of coal producing about 129 thousand megawatt-hours from 20,000 megawatts of electricity generating capacity.

However, existing coal-fired electric generation is poorly suited to carbon management. In particular, capture of carbon dioxide from post-combustion exhaust streams is extremely difficult and expensive. Even new technology coal-fueled electric generation options like integrated gasification combined cycle (IGCC) power plants pay a high price for carbon management. If carbon management legislation is passed, electric utilities will be forced to shift generation capacity to nuclear and/or renewable sources of generation. Developing a CTL fuels industry will protect the Kentucky coal industry as this change in electric generation occurs.

Conventional gasoline and diesel fuel have a well-to-wheel carbon dioxide emission rate of 25.4 pounds per gallon and 26.5 pounds per gallon, respectively (van Vliet, 2007). Assuming a 50/50 mix of gasoline and diesel fuel from the Kentucky CTL fuels industry (since characteristics of jet fuel are more similar to diesel than gasoline), the average carbon dioxide emissions from a gallon of conventional fuel would be 26 pounds per gallon. Applying a two-to-one emission factor for the well-to-wheel emission of a gallon of F - T fuel gives 52

In 2006 Kentucky burned 42 million tons of coal to generate approximately 15,500 megawatts of electricity, so the 50 million tons of coal the fully developed CTL industry would use could produce about 18,500 megawatts. Using a factor of three million tons of carbon dioxide emitted for every 500 megawatts of coal-fired electricity generated (DOE, EPA, EIA, 2000), then 50 million tons of coal per year used to generate electricity would emit 111 million tons of carbon dioxide per year. Therefore, even without using CCS to manage the carbon dioxide generated in the manufacture of CTL fuels, the reduction in carbon dioxide emitted per year by diverting 50 million tons of coal from pulverized coal electricity production to CTL fuel production would be 48 million tons of carbon dioxide per year, a decrease of almost 44 percent. If CCS were used to control 90 percent of the carbon dioxide emitted in the CTL fuels manufacturing process, then the reduction would be over 94 percent.

pounds per gallon. Burning a gallon of gasoline or diesel fuel produces 19.4 and 21.9 pounds of carbon dioxide respectively, so the average emission from a gallon of CTL fuel is 20.7 pounds per gallon and the manufacturing carbon dioxide contribution is $52 - 20.7 = 31.3$ pounds per gallon. Approximately 80 gallons of fuel are produced from a ton of coal, so the 50 million tons of coal used by the recommended CTL fuels industry would emit 63 million tons of carbon dioxide in the manufacture of the liquid fuels. But because the carbon dioxide is more easily captured in CTL processing than with electricity generation, CCS is much more practical and economical.

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Strategy 5:

Implement a Major and Comprehensive Effort to Increase Gas Supplies, Including Coal-to-Gas in Kentucky

GOAL Kentucky will produce the equivalent of 100 percent of our annual natural gas requirements by 2025 by augmenting in-state natural gas production with synthetic natural gas (SNG) from coal-to-gas (CTG) processing.

INTRODUCTION

The Kentucky natural gas industry produces about 44 percent of the total gas requirements of the commonwealth. As in many other states, Local Distribution Companies (LDCs) in Kentucky obtain most of their gas requirements from external sources rather than from local production. Most of the gas produced in Kentucky is dedicated to the interstate market.

Being largely dependent on external sources of gas, consumers in Kentucky pay added transportation costs for most of the gas that they use. The average pipeline demand cost for delivery of gas to the five major LDCs in Kentucky is about \$0.90 per thousand cubic feet. More importantly, consumers in Kentucky, as in other states, become vulnerable to possible supply uncertainties and price increases and spikes as these may occur in the U.S. natural gas system and market.

Virtually all of the gas needs of Kentucky can be met by natural gas production augmented by synthetic natural gas produced by gasifying coal. To the extent that locally produced SNG becomes available, consumers in Kentucky will not pay interstate transportation costs and will be less likely to encounter supply uncertainties. Also, if Kentucky SNG can be obtained on long-term contract, consumers will less likely be affected by price increases and spikes that may occur in the U.S. natural gas market. Synthetic natural gas production in Kentucky can also create a large new market for Kentucky coal.

Synthetic natural gas produced by gasifying coal would complement a strong conventional natural gas industry in Kentucky.

Kentucky Natural Gas Situation

Resources and Production

The Kentucky Geological Survey (KGS) estimates that Kentucky natural gas resources exceed 12 trillion cubic feet, or enough for 120 years of production at the current rate of just over 95 billion cubic feet per year (KGS, 2008c). Although Kentucky has substantial natural gas resources, and natural gas consumption in Kentucky is moderate compared to other states, annual marketed gas production in the commonwealth is substantially less than total gas demand in the commonwealth. In 2006, 216 billion cubic feet of natural gas were consumed in Kentucky (Table 7) while production was just over 95 billion cubic feet (Table 6), which corresponds to 44 percent of consumption.

Although natural gas production in Kentucky has never reached even half of current consumption in Kentucky, there are indications that production could increase substantially due to the push of increasing gas prices, increased use of unconventional gas production technology, and exploration underway. Already, higher natural gas prices have resulted in increased drilling and production.

However, the traditionally low flow rate of wells in Kentucky indicates that production may continue to be substantially below the level of gas consumption in Kentucky unless larger new resources are found and developed or unless improved production can be obtained by use of unconventional gas production technology and techniques.

The KGS reports that while known natural gas resources in Kentucky total 12 trillion cubic feet, speculative resources may total another 114 trillion cubic feet, with the greatest part of those speculative resources being in the Devonian shale formations which account for virtually all of the known resources and production. Another major unconventional resource is coal bed methane which the KGS estimates at 0.848 trillion cubic feet (KGS, 2008b).

Production in Kentucky has traditionally been characterized by numerous wells but relatively low flow from those wells. In 2006, Kentucky accounted for 3.5 percent of producing gas wells in the United States, but these wells produced only 0.5 percent of U.S. natural gas (EIA, 2008h). In 2006, 77.5 percent of production in Kentucky came from gas wells in the lowest production bracket of 10 barrels per day oil equivalent (10 BOE per day). More than 94 percent of gas wells in Kentucky were reported to be in this production rate bracket. In contrast, gas wells in this lowest category in the United States as a whole accounted for only 7.9 percent of total U.S. production. About 65 percent of wells in the United States were reported to be in this production rate bracket (EIA, 2006b).

Table 6: Wellhead Price, Marketed Production, and Producing Natural Gas Wells in Kentucky, 2001-2006

	2001	2002	2003	2004	2005	2006
Wellhead Price (Dollars per Thousand Cubic Ft.)	4.78	3.01	4.54	5.26	6.84	8.83
Marketed Production (Million Cubic Ft.)	81,723	88,259	87,608	94,259	92,795	95,320
Producing Wells	14,370	14,367	12,900	13,920	14,175	15,892

Source: USEIA. Natural Gas Data. http://tonto.eia.doe.gov/dnav/ng/ng_prod_whv_dc_u_SKY_a.htm; http://tonto.eia.doe.gov/dnav/ng/ng_prod_wells_sl_a.htm.

Table 7: Natural Gas Delivered to Customers in Kentucky, 2002-2007 (million cubic feet)

	2002	2003	2004	2005	2006	2007
Volumes Delivered to Consumers	211,950	206,023	212,556	222,222	200,350	215,727
Residential	59,104	61,886	56,443	56,142	47,379	51,956
Commercial	35,942	38,212	36,989	36,894	32,590	34,606
Industrial	103,112	102,272	114,292	112,004	108,094	109,679
Vehicle Fuel	80	98	110	27	30	NA
Electric Power	13,712	3,667	4,833	17,181	12,287	19,486

Source: (USEIA. Natural Gas Data. http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dc_u_SKY_a.htm).

Prospects for Increased Production in Kentucky

Table 8 indicates that drilling and production in Kentucky have responded to price increases in recent years. Between 2001 and 2006, the average wellhead price increased from \$4.78 per thousand cubic feet to \$8.83 per thousand cubic feet, or an 85 percent increase. The number of producing wells in Kentucky increased during that time by over 1,500 (or 10.6 percent), and marketed natural gas production increased by 13.6 billion cubic feet or 16.6 percent. It appears that under the current production conditions, in which the great majority of wells in Kentucky are in the lowest production rate bracket, a very large number of wells would have to be added to increase Kentucky natural gas production to near current consumption levels. Alternatively, production levels would have to be increased by adoption of new technologies or production techniques.

EIA has recently reported that, after nine years of no growth, natural gas production in the Lower 48 States started an upward trend with three percent growth between the first quarter of 2006 and the first quarter of 2007. This was followed by an exceptionally large nine percent increase between first quarter 2007 and first quarter 2008. DOE attributes this increase largely to the use of unconventional production such as horizontal drilling, and notes that horizontal drilling is becoming the primary method used to produce gas from geologic formations like shale (EIA, 2008c).

Gas experts in Kentucky report that recent tests of horizontal drilling in shales like those in Eastern and Western Kentucky have yielded very large flow rates. The KGS reports that Equitable Resources, one of the largest gas producers in Kentucky, has proposed and is on track to drill 200 horizontal wells in Eastern Kentucky. The company reports extremely successful tests of horizontal and related lateral drilling that have yielded very large gas flows (Collings, 2008). There is tremendous potential for shale gas production in both Eastern and Western Kentucky that is limited primarily by the availability of rigs, steel, skilled labor, and infrastructure including pipelines (Nuttall, 2008).

A second large company operating in Kentucky, Chesapeake Energy, reports extensive involvement in unconventional gas production in several areas of the United States. Although Kentucky is not mentioned, it may be assumed that the techniques might be applied in Kentucky before long (Chesapeake Energy, 2008). A third large company operating in Kentucky, NGAS, is also expanding horizontal drilling (Wallen, 2008).

Potential New Resources

The KGS is conducting research on potentially large resources, especially in deeper formations that may contain large natural gas pockets. The Rough Creek Graben Project in the Grayson County area, appears to have especially strong potential for large and deep gas pockets (KGS, Rough Creek Graben, 2008f). Other similar resource characterization is being conducted in the Rome Trough formation in Eastern Kentucky and the East Continent Rift Basin in Western Kentucky (KGS, 2008e).

In recent years, interest has grown concerning potential production of methane from coal beds. In 2004, the Kentucky General Assembly enacted legislation concerning development of coal bed methane, addressing numerous issues including ownership of the gas and safety. A few potential developers conducted assessments of production potential a few years ago. Since that time, there has been little development activity. According to the KGS, issues that may affect future development

activities include, in addition to ownership and safety, the lower methane content of much of Kentucky's coal and infrastructure. Developers will not only have to drill for the methane, they will also have to construct pipeline facilities to move the gas to market (Nuttall, 2008).

Infrastructure Obstacles

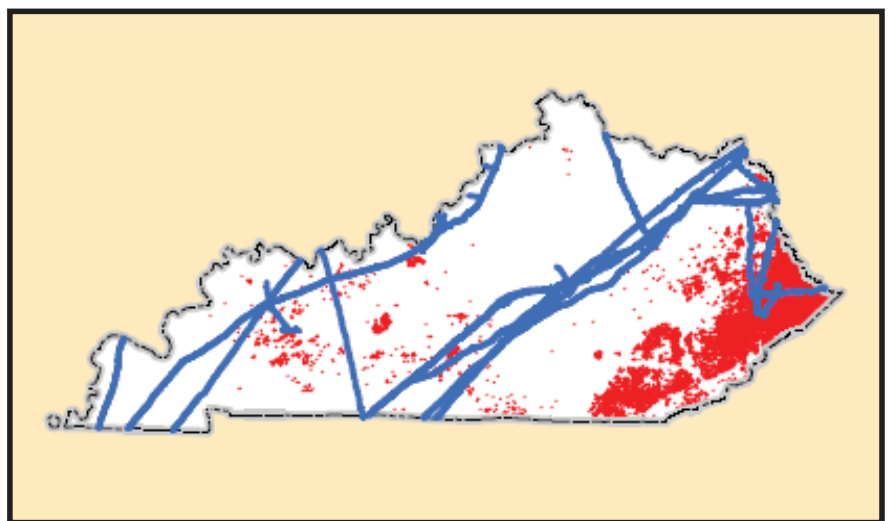
In recent years, infrastructure has presented obstacles to increased natural gas production in Kentucky. The obstacles have been most pronounced in Eastern Kentucky where inability to obtain pipeline capacity for moving gas to interstate pipelines for delivery to Northeastern markets has resulted in decreased production in Eastern Kentucky (Baird, 2005).

Several actions have been taken to address actual or potential problems of inadequate pipeline infrastructure. In 2005, the Kentucky General Assembly created the Kentucky Gas Pipeline Authority to facilitate the construction, reconstruction, improvement or repair of any gas transmission pipeline and appurtenant facilities in the commonwealth (KRS 353.750-776). And in 2006, the Federal Energy Regulatory Commission approved construction and operation of a new 68-mile pipeline from Floyd County to an interconnection in Carter County with an interstate pipeline. The pipeline, built by Equitable Resources subsidiary Equitrans, can transport up to 1,300 thousand cubic feet per day or enough to heat about 400,000 homes per year (Equitable Resources, 2006).

Industry representatives report that access to pipeline capacity continues to be a major and increasing problem in Kentucky. Recent increases in production, largely due to increased use of horizontal drilling techniques, are causing pipelines serving the producing areas to be fully subscribed and unable to accept additional gas for movement to markets via interstate pipelines. Producers are concerned that they will have to shut-in current producing wells and severely reduce their plans for expanding production. The commonwealth would, consequently, lose the economic benefits of employment and severance tax revenues as well as indirect and continuing economic activity that would result from natural gas production (Gabbard, 2008).

Kentucky Natural Gas Market

Because of the location of the major gas fields in Kentucky, most gas produced in Kentucky enters the interstate market via major pipelines that traverse the commonwealth. Most gas production in Kentucky occurs in far eastern counties (Figure 19). In 2006, Eastern Kentucky accounted for almost 99 percent of Kentucky's total natural gas production of over 95 billion cubic feet. Pike County, the easternmost county, produced over 32 billion cubic feet, one-third of total Kentucky



Source: Kentucky Public Service Commission

Figure 19: Natural Gas Producing Areas and Transmission Pipelines in Kentucky

gas production in 2006 (computed from KGS, Oil and Gas Production Data, 1980 – 2007). The counties in the Big Sandy area contain a dense network of transmission lines that move gas to the major interstate pipelines which traverse Kentucky from southwest to northeast, carrying over 21 percent of all the natural gas consumed annually in the Eastern United States (calculated from EIA Gas Data, various tables).

As noted, Western Kentucky may have large deep resources capable of both providing a greater part of Kentucky gas requirements from indigenous production and of marketing the gas throughout the commonwealth via the existing pipeline network. The KGS is exploring the potential for such large deep reserves in the Grayson County area of Western Kentucky. At this time, it is not known if such resources exist or can be economically developed (KGS, 2008f).

Economic Benefits of Production

The economic impact of natural gas production in Kentucky is significant. In 2007, over 2,300 persons worked in natural gas production in Kentucky, earning nearly \$112 million in wages and salaries (Kentucky Department of Workforce Investment). The production of natural gas in Kentucky generated severance tax revenues of \$32.6 million in fiscal year 2007 (Kentucky Department of Revenue).

Consumption

Natural gas is important to Kentucky's continued economic growth, especially industrial growth. Both total natural gas consumption and gas consumed by residences in Kentucky are about average among the states, ranking 27th and 25th respectively. However, consumption by industrial plants is in the top one-third of the states, ranking 16th. In expenditures for natural gas by industry, Kentucky ranks 13th among the states (EIA, 2005). Use of natural gas in electricity generation in Kentucky is small; however, Kentucky, like the rest of the United States, may see greatly increased use of gas in generation in coming years. A recent report by the U.S. Department of Energy National Energy Technology Laboratory showed that the United States will likely experience a substantial increase in natural gas consumption for several years following enactment of federal climate change legislation since about 18 gigawatts of coal-fired electricity generation capacity is forecast to be replaced by generation from natural gas units (NETL, 2008). Although it is not clear how much gas-fired electricity generation will replace coal-fired in Kentucky, it may be expected to be significant.

Kentucky Reliance on External Sources

Because of the nature of Kentucky's resources, production and transportation systems, natural gas consumed in the commonwealth comes predominantly from producing areas to the southwest. It is important to understand that this is not unusual. Few states produce sufficient gas to meet all of their needs. Also, it is a common practice for the gas industry in a state to displace gas that is shipped to out-of-state markets with gas brought into the state rather than constructing and operating pipelines sufficient to deliver in-state gas to all in-state markets.

Supply Uncertainties

States, including Kentucky, for which substantial parts of their gas requirements are transported by pipeline from external producing areas have in recent years encountered supply uncertainties.

Hurricanes have significantly curtailed or threatened to curtail production in the Gulf region (Stanley, 2006). The vulnerability of the transportation network to terrorism has become of increased concern. The possibility of supply-threatening accidents is always present. In 1976 – 1977, a combination of a production shortfall caused largely by federal price control policy along with greatly increased demand due to severe winter weather caused curtailment of gas supply in Kentucky (U.S. DOE *U.S. Energy Policy, 1980 – 1988*). This was an extreme situation, and Kentucky experienced a moratorium on new natural gas service and numerous schools and businesses closed for a time.

Price Impacts

In recent years, the U.S. average wellhead price of natural gas has more than tripled, increasing from about \$2.00 per thousand cubic feet in 2000 to over \$6.00 in 2007 (Figure 20). Figure 20, which shows prompt month (delivery the next month) natural gas futures prices, indicates that consumers have been subject to severe price spikes in recent years. The spikes that occurred in 2000 and 2002 were due to a combination of weather, lagging production, and shortfalls in storage. A major spike also occurred when hurricanes in the late summer of 2005 took over 80 percent of Gulf offshore gas production off-line, causing a cumulative loss by the end of November 2005 of almost 14 percent of total annual production in the area (Stanley, 2006).

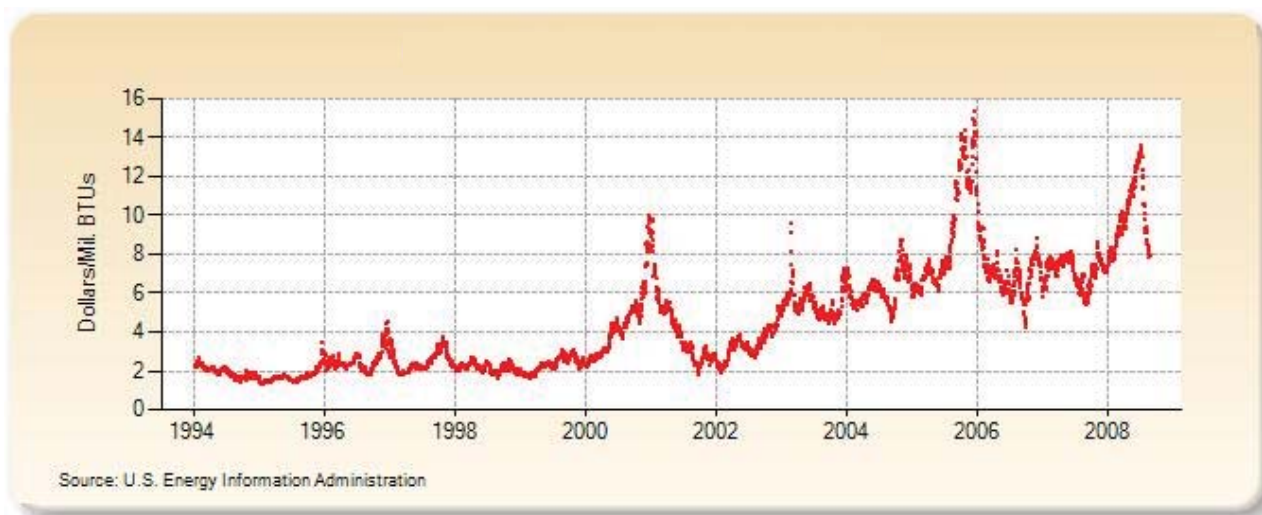


Figure 20: Daily Natural Gas Futures Contract, January 1, 1994 – August 12, 2008

<http://tonto.eia.doe.gov/dnav/ng/hist/rngc1d.htm>.

It is very difficult to predict just where natural gas prices will be in coming years. The tripling of price in recent years has been largely due to decreasing production capacity coupled with increasing demand, largely for electricity generation. U.S. production capacity peaked at 55 billion cubic feet per day in 1994 (Yergin, 2004). Similar to production in Kentucky, increasing numbers of producing wells in the United States have been producing less total volume. Table 8 shows that the number of producing gas and condensate wells in the United States increased by 61,079, or 15.8 percent from 2002 through 2006 while marketed production actually decreased by 602.9 billion cubic feet, or three percent. The severe spikes in price of recent years have been due largely to weather and perceived potential shortfalls in storage, as noted above.

There are indications, that, over the long-term, the U.S. natural gas supply situation could improve and put downward pressure on prices, although gas prices steadily increased from the beginning of 2008 through July. Since July, prices have decreased precipitously. EIA attributes this decrease to increased onshore gas production, lower oil prices, mild weather, and substantial increases in storage. EIA predicts that, unless weather becomes severely hot, prices will not rise until winter and then only moderately because of increased production and lower oil prices (EIA, 2008g). It can be expected that weather, storage, and oil prices will continue to strongly influence short-term gas prices. It is unclear how recent increases in production, the first such increases in several years, will impact gas prices in the future. How long production increases will continue remains to be seen. However, it appears quite certain that proposed federal climate change legislation will dramatically increase demand and put upward pressure on the price of natural gas in the long-term.

Table 8: Marketed Production of U.S. Natural Gas and Producing Wells in the U.S., 2002 - 2006

	2002	2003	2004	2005	2006
Production (million cubic ft)	19,984,780	19,974,360	19,517,491	18,927,095	19,381,895
Producing wells	387,772	393,327	406,147	425,887	448,841

Source: (USEIA. Natural Gas Data. http://tonto.eia.doe.gov/dnav/ng/ng_prod_whv_dc_u_nus_a.htm; http://tonto.eia.doe.gov/dnav/ng/ng_prod_wells_sl_a.htm))

Climate Change Legislation Impacts on U.S. Natural Gas Demand and Price

Although production is up and is influencing gas prices, climate change legislation is expected to cause dramatically increased demand and prices for U.S. natural gas. Recent analyses of the potential impacts of major policy changes, most notably S. 2191, the Lieberman-Warner Climate Security Act of 2007, indicate that demand for natural gas will increase strongly in the first several years after climate change legislation is enacted because gas will be the only alternative in the short-term to coal-fired electricity generation. The studies also find that in the long-term, to about 2030, the price of gas will further increase because of the carbon content in natural gas. Expected price increases for 2030 over the \$5.80 per thousand cubic feet base case (not including input from Lieberman-Warner) range from 22 percent (American Council for Capital Formation), to 57 percent (Environmental Protection Agency), to up to 81 percent (EIA – residential delivered price), to as much as 146 percent (National Association of Manufacturers). Thus, there is substantial uncertainty in natural gas price increases due to potential carbon management legislation.

The major variables affecting the future demand for and price of natural gas in these studies are the speed of deployment of new nuclear units, increased use of renewables, the timely development and demonstration of carbon capture and sequestration, and policies concerning offsets. In its analysis of the impacts of S. 2191, EIA stated that the analysis shows “the importance of development and deployment of key low-carbon generating technologies like nuclear, renewables, and fossil with CCS in a timeframe consistent with the emission reduction requirements of legislation similar to Lieberman-Warner. Without them, allowance prices would be higher and greater demands would be placed on natural gas markets” (EIA, 2008d).

Imports of Liquefied Natural Gas (LNG)

The combination of declining U.S. natural gas production, normal increase in natural gas demand, and the likelihood of greatly increased demand for natural gas for the first decade or so following potential federal climate change legislation will result in increased need for imports of natural gas. Whereas the United States has for some years imported about 15 percent of its natural gas requirements from Canada, the imports will almost entirely cease by 2030. EIA forecasts that net imports of natural gas from Canada will decrease from 2.9 trillion cubic feet in 2006 to 0.3 trillion cubic feet in 2030 (EIA, 2008a). Imports from Canada are being decreased by Canadian government policy in order for the gas to be available for use in the production of heavy oil from the vast tar sands formations in Alberta. The loss of imports from Canada will be made up by LNG imports which will increase from 0.5 trillion cubic feet in 2006 to 2.8 trillion cubic feet in 2030 (EIA, 2008a).

Relying on LNG imports is problematic. Development of an LNG terminal can take several years, and there is indication that LNG terminals may have difficulty in gaining necessary state and federal approvals in coastal areas. Also, LNG is subject to the same international commodity market vagaries that have made imports of petroleum increasingly unreliable and costly. Early expectations that development of LNG systems would cause world gas prices to clear at about \$3.50 per thousand cubic feet have been replaced by competitive bidding behavior among gas-short countries that has diverted shipments away from the U.S. even when gas prices in the U.S. are above \$10 per thousand cubic feet. Thus, given increasing world demand, LNG is likely to be very expensive (NETL, 2008). It can also be expected that gas surplus countries that sell on the LNG market may exhibit the same cartel behavior as OPEC.

The reliability problems of LNG are currently being experienced, as noted in the following statement in the June 26, 2008 EIA Natural Gas Weekly Update:

“The pace of deliveries of liquefied natural gas (LNG) imports remains considerably below last year’s volumes and now appears to have been less than 200 billion cubic feet for the first half of the year, which is less than half of the approximately 460 billion cubic feet received last year during the same time period. LNG imports in June have averaged about 0.9 billion cubic feet per day (based on sendout data from LNG import terminals), which is significantly less than the average of 2.8 billion cubic feet per day in June 2007. Most flexible LNG cargoes are heading to Europe and Asia, where buyers continue to purchase LNG at prices higher than those that have prevailed in U.S. markets” (EIA, 2008f).

Great Plains Synfuels Plant

Created in response to the energy crises of the 1970s and 1980s, the Great Plains Synfuels Plant since 1984 has produced 54 billion cubic feet of pipeline quality synthetic natural gas (SNG) each year by gasifying about six million tons per year of lignite, a relatively low grade of coal. The Great Plains Synfuels Plant is the only coal to SNG plant operating in the United States.

SNG leaves the plant via a two-foot diameter pipeline, traveling 34 miles south. The pipeline joins the Northern Border Pipeline, which transports the gas to four pipeline companies. These companies supply thousands of homes and businesses in the eastern United States.

Of major importance to the future of meeting America’s energy needs by gasifying coal, the plant sells captured carbon dioxide to oil producers for enhanced oil recovery in a mature oil field in Canada.

Coal-to-Gas (CTG) Technology

Production of synthetic natural gas (SNG) by gasification of coal is an established and proven technology. The process is similar to production of diesel and jet fuel by gasification of coal, but the SNG process is simpler and less costly. Both processes use catalysts to convert synthesis gas produced by gasification of coal and made up primarily of H_2 and CO into liquid and gaseous fuels.

In a 2007 study, the UK Center for Applied Energy Research reported:

“The production of synthetic natural gas ... is a way of converting coal into the equivalent of pipeline quality natural gas. The technology involved in SNG production is much less cumbersome than for CTL. The main reaction is to convert the syngas produced from coal gasification to methane in a methanation reactor, and the product gas is then adjusted to meet natural gas pipeline specifications. The reaction is typically catalyzed by nickel catalysts and it is best performed at high temperatures ... where additional heat is liberated that can be used in the gasification process. Commercial catalysts and technology are available.

SNG from coal is particularly attractive in situations where relatively cheap coal is available while there is demand for natural gas (methane) which can be logistically transformed or when natural gas prices are high enough to sustain the economics” (CAER, 2007).

CTG Economics

Estimated prices of SNG compare very favorably with the \$14.00 per thousand cubic feet wellhead price of natural gas in July, 2008. The prices compare even more favorably with the city gate price of natural gas which includes the cost of transporting the gas from production areas in the Gulf region.

In a study conducted for the CAER, Mitretek Corporation modeled costs and efficiencies of generic non-site specific small CTG plants utilizing about 5,000 tons per day of coal. The analysis showed that such a plant can produce about 74 million cubic feet of SNG per day at a capital cost of about \$900 million. The cost of the SNG would be \$9.10 per thousand cubic feet for a plant using East Kentucky coal priced at \$35 per ton and not capturing carbon. The cost would be \$9.47 per thousand cubic feet for a plant using East Kentucky coal priced at \$35 per ton and capturing carbon (but not sequestering or marketing it). The cost would be \$9.39 per thousand cubic feet for a plant using West Kentucky coal priced at \$30 per ton and not capturing carbon. Mitretek did not analyze the cost of a West Kentucky plant that captured carbon. The CAER also found that larger plants can achieve economies of scale which can reduce the cost of production to between \$7.50 to \$8.00 per thousand cubic feet (CAER, 2007).

A study done in 2008 by URS Corporation estimated that a larger generic, non-site specific SNG plant in West Kentucky capable of converting about 12,000 tons per day of coal into SNG would have a capital cost of approximately \$1.7 billion, including the cost of capturing but not sequestering carbon dioxide. Such a plant could produce about 175 million cubic feet of SNG per day at an estimated cost of production of SNG of \$7.96 per thousand cubic feet, assuming a coal

price of \$30 per ton. The URS report stated that the price of SNG would increase about 34 cents for each \$5 increase in the cost of coal (URS Corporation Pipeline Group, 2008). A lower-quality West Kentucky coal would currently sell for about \$50 per ton (perhaps substantially less on long-term contract). According to the URS assumptions, the increase in the price of coal from the assumed \$30 per ton to the more current \$50 per ton would increase the cost of SNG by \$1.36 per thousand cubic feet raising the price to \$9.32 per thousand cubic feet.

Meeting Kentucky's Natural Gas Requirements with SNG

The business-as-usual case in EIA's forecast of U.S. natural gas consumption shows an increase of almost 10 percent between 2006 and 2016. Between 2017 and 2030, U.S. natural gas consumption is forecast by EIA to decrease by almost five percent (EIA, 2008). Assuming that the same growth rates would apply in Kentucky, the commonwealth's 2006 natural gas consumption of 215 billion cubic feet in 2006 would increase to 237 billion cubic feet in 2016 and would decrease to 225 billion cubic feet in 2030.

A small CTG plant such as the plant analyzed by the CAER that produced 74 million cubic feet of SNG per day would produce about 27 billion cubic feet of SNG per year. Thus, to meet 100 percent of Kentucky's natural gas requirements at the high point of consumption between 2006 and 2025 (i.e., 237 billion cubic feet in 2016) would require about five CTG plants capable of producing 27 billion cubic feet per year each, assuming that the current natural gas production rate is maintained.

It should be noted that there are numerous possible plant sizes and configurations. The CAER chose the 5,000 ton-per-day size from which extrapolations could be made about larger plants. The CAER does not estimate how large an optimally economically viable plant would be.

The generic plant analyzed by URS Corporation may be a more optimal size. That plant would cost about \$1.7 billion. It would convert about 12,000 tons per day of coal (about 4.4 million tons per year) into 175 million cubic feet per day, or 64 billion cubic feet of SNG per year. It would require between two such plants to meet the high point (237 billion cubic feet in 2016) of Kentucky's projected gas requirements between now and 2030 assuming natural gas production grows slightly.

The only commercially operating CTG plant in the United States is the Dakota Gasification Plant in North Dakota. That plant utilizes about six million tons per year of lignite, a very low grade (low Btu, high moisture) coal, to produce 54 billion cubic feet per year of SNG (Dakota Gasification Co., 2008). Given differences in coal quality and scale, the generic plants analyzed by the CAER, Mitretek and URS Corporation appear to compare well with the Dakota Gasification Plant.

CTG Economic Benefits

The CAER estimated that the small CTG plant that it analyzed would cost about \$900 million, including carbon capture (but not storage). The plant would require about 5,000 tons per day of coal or about 1.8 million tons per year. They estimated that about 240 miners would be employed in producing the coal and 650 – 1,100 people would be required to construct the plant and 190 employees would be required for plant operation (CAER, 2007). The CAER did not estimate how long construction would take, but the construction time most often cited in the many projects that have been proposed in recent years is four years (CAER, 2007).

The economic benefits of the construction and operation of five such plants to complement existing natural gas from wells would be significant. Total construction costs of the five plants would be over \$4 billion. Up to 5,500 construction jobs would be created. Each plant would consume 1.8 million tons of coal, resulting in new annual coal demand when all five plants are in operation of about nine million tons per year. A total of 950 new jobs in plant operation would be created.

Kentucky LDC Long-term Contracting Policy

Perhaps the major benefit of SNG production is, as discussed above, ending Kentucky's dependence on natural gas from external sources and vulnerability to supply interruptions and to price increases and spikes that may occur in the United States natural gas market. Kentucky has already taken legislative action to ensure that natural gas local distribution companies can take advantage of the predictable prices that SNG can provide.

KRS 278.5085 (SB 131, enacted 2007) provides for approval by the Kentucky Public Service Commission of the purchase by an LDC of up to 25 percent of gas needs from SNG producer(s). The price of the SNG is to be set at the average of 60 months futures price for natural gas at the Henry Hub. The price may vary by no more than \$1.50 per thousand cubic feet over the life of the contract.

Figure 21 illustrates how the statute would set the price of gas in a contract initiated on July 1, 2008 between an LDC and a producer of SNG. The average of the next 60 months Henry Hub futures prices shown on Figure 21 is \$11.609 per thousand cubic feet. The allowable price adjustment of \$1.50 would create a range between \$11.61 per thousand cubic feet and \$13.10 per thousand cubic feet. This set price which would be in effect for 25 years smoothes out the severe spikes of recent years. It also seems very likely to be less than the price increases predicted by many. As noted earlier in this report, analyses of the impacts of the Lieberman-Warner bill predict price increases over the EIA forecast price for 2030 of 22 – 146 percent.

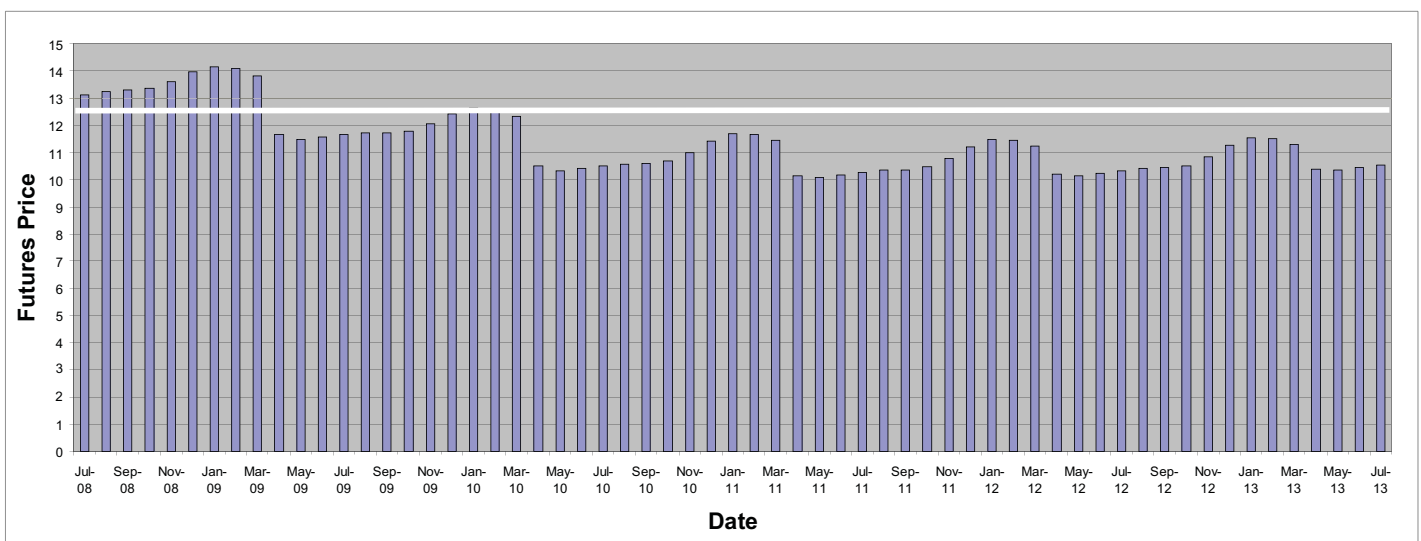


Figure 21: NYMEX Natural Gas Futures

Source: Chart created from data provided by Natural Gas Intelligence. http://intelligencepress.com/data/futures/nymex_report.emb?trade_date=2008-06-26&commodity=NG.

In addition, creation of an assured supply of gas at predictable prices by development of an SNG industry in Kentucky can lay the groundwork for developing industry in Kentucky that utilizes natural gas as feedstock or for heat in industrial processes. The National Energy Technology Laboratory has reported that "(I)n trade-exposed sectors of industry, especially aluminum, fertilizer, and chemicals, the rise in natural gas prices, which in the first part of the decade was U.S.-centric, caused production to be shut in or moved offshore." Also, Middle Eastern production of chemicals especially, threatens the competitive position of U.S. industry because of cheap natural gas reserves in the Persian Gulf area (NETL, 2008). Both factors reinforce the importance of a CTG industry in Kentucky.

ACHIEVING THE GOAL

Kentucky will produce the equivalent of 100 percent of our annual natural gas requirements by 2025 by augmenting in-state natural gas production with synthetic natural gas (SNG) from coal-to-gas (CTG) processing.

Near-Term Actions (1-3 years)

Kentucky has already taken major actions that enable the production and utilization of SNG in the commonwealth. These include:

1. Establishment of incentives for attracting CTG plants to Kentucky.
 - Kentucky Incentives for Energy Independence Act, 2007 (KRS 154.27-020). Tax incentives for up to 25 years, up to a maximum of 50 percent of the capital investment, include:
 - Sales and Use Tax refunds up to 100 percent of tax paid on tangible personal property made to construct, retrofit or upgrade a facility.
 - Severance Tax incentives up to 80 percent of taxes paid on the purchase or severance of coal.
 - Tax Credits up to 100 percent of tax paid on corporate income or Limited Liability Entity Tax arising from the project.
 - Wage Assessment incentives up to four percent of gross wages of each employee.
 - Commercialization Grants Program
 - Grants for economic and technical feasibility studies. Several assessments are underway; two are for potential CTG plants.
2. Statutory authorization KRS 278.5085 for the Kentucky Public Service Commission to approve purchase by Kentucky Local Distribution Companies (LDC's) of gas from SNG producers.
3. Preparation of a bank of potential sites for plants utilizing coal gasification.
 - About 29 potential sites have been nominated by local governments, industry, and others. These have been characterized by size, configuration, access to coal, access to pipelines, market for products, carbon sequestration potential, etc. Specific follow-on tasks are proposed.
 - Pre-permit the most promising sites.
 - Conduct preliminary carbon sequestration assessment on the most promising sites.
 - Drill wells at the most promising sites to assess host strata, cap strata, potential volume that can be sequestered.

In addition to the actions already underway, it is recommended that the following also be done in the short term:

1. Expand catalysis research at CAER to focus on methanation for SNG production.
2. Expand research at CAER to include the life-cycle carbon reduction potential of gasifying biomass with coal in CTG processes.
3. Initiate a PSC administrative case to ensure that Kentucky local distribution companies (LDCs) and customers are not harmed by direct sales of gas from SNG producers to industrial plants. The PSC conducted Administrative Case 297 in 1986, when the natural gas market was deregulated by federal legislation and set policies concerning bypass of LDCs by industry desiring to purchase directly off pipeline.
4. Expand and accelerate assessments of new gas resources in Kentucky.
5. Initiate a comprehensive study of pipeline infrastructure in Kentucky to determine needs in relation to expanded production of natural gas and coal-bed methane.

Mid-term Actions (3-7 years)

1. Continue research on carbon dioxide reduction potential of gasifying biomass along with coal.
2. Review effects on similar or competing energy policies, e.g., exploration for new deep gas reserves.
3. Analyze the need for legislation to allow investment in SNG plants by Kentucky LDCs and electric generators.
4. Assess pipeline infrastructure adequacy for serving Kentucky markets and interstate markets by CTG industry.
5. Assess carbon dioxide pipeline infrastructure needs.

Long-term Actions (>7 years)

1. Continue research, demonstration and deployment of carbon sequestration.

IMPLEMENTATION SCHEDULE

A new SNG plant started today would require about seven years to begin operation, assuming three years to obtain all necessary permits and four years for construction and start-up. For the purpose of estimating coal demand from operation of five SNG plants in Kentucky, it is assumed that a first plant is announced now and requires seven years to begin operation and that one other plant begins the process soon and also is ready for production in seven years, or in 2015. It is assumed that two additional plants come on line in 2020 and that the final plant comes on line by 2030.

As the first two plants come on line in 2015, coal demand will increase by 3.6 million tons per year in 2015. Coal demand will increase an additional 3.6 million tons per year in 2020 as two additional plants come on line. Coal demand will increase by an additional 1.8 million tons per year in 2030 as the final plant comes on line.

Since coal production for coal-fired power plants is likely to decrease substantially due to climate change legislation, the new demand would be replacing some lost production. The National Energy Technology Laboratory estimates that nationally the Lieberman-Warner bill, if enacted, could cause the cancellation of 18 gigawatts of planned coal-fired electricity generation capacity in 2016. (NETL, 2008). A one-gigawatt plant consumes approximately 3.5 million tons per year of coal (Kentucky Utilities, 2008). Eighteen gigawatts of capacity would require 63 million tons per year of coal. In 2006, Kentucky accounted for 10.4 percent of U.S. coal production (Kentucky Coal Facts, 2007-2008). If Kentucky lost its proportionate share of the deferred coal production due to the cancellation of 18 gigawatts of coal-fired generating capacity, Kentucky coal production by 2016 would be reduced by 6.6 million tons per year.

Kentucky coal production can meet the new demand in 2015, 2020, and 2030. First, there is considerable ability to expand production with existing infrastructure. In 1990, Kentucky produced over 170 million tons of coal. In 2006, production had declined to 121 million tons. Expansion to 178 million tons by 2015 is achievable. An example of rapid expansion of production is the new River View mine being opened by Alliance Coal in Union County (Alliance Resource Partners, 2008). Originally planned as a three million ton-per-year mine, the mine when it opens in a year or so, will produce six million tons per year.

ENVIRONMENTAL BENEFITS & LIMITATIONS

SNG plants, as part of their design requirements, separate and can capture virtually all carbon dioxide produced. The CAER estimates that the small 5,000 ton-per-day plant with carbon capture would produce 8,382 tons of carbon dioxide per day, or just over three million tons per year. The plant would capture 8,217 tons per day, or 98 percent (CAER, 2007). According to CAER, the removal of carbon dioxide in the CTG process imposes a small efficiency penalty of about two percent and a cost of production penalty of about four percent. The CAER estimate is for separation, capture, and pressurization of carbon dioxide but does not include the cost of storing, transporting, or sequestering the carbon dioxide.

Five small plants sufficient to meet Kentucky's natural gas requirements would produce a total of 15 million tons of carbon dioxide per year when all are in operation in 2030. At 98 percent capture, if the plants could sequester carbon dioxide, there would be a net increase of 120 thousand tons of annual carbon dioxide emissions in 2015, an additional 120 thousand tons in 2020, and an additional 60,000 thousand tons in 2030. In 2030, total additional carbon dioxide emissions would be 300 thousand tons per year while almost 15 million tons would be captured and sequestered. This is much lower than if the nine million tons of coal per year were used for coal-fired electricity generation.

It may be possible to actually reduce life cycle carbon dioxide emissions by gasifying biomass along with coal to produce the SNG. Research by the Idaho National Laboratory recently showed that liquid transportation fuels produced by the Fischer-Tropsch process in which coal is gasified to produce syngas which is transformed under catalysis into liquid fuels can emit less life-cycle carbon dioxide than conventional transportation fuels when coal and biomass are gasified together in 70/30 proportions, respectively, and the produced carbon dioxide is sequestered (Baard Energy, 2007). It would appear that the same carbon dioxide reductions could be achieved in CTG processes since the first stage, the gasification of coal, is the same in CTG as in CTL. Research is

needed to determine if the gasification of biomass along with coal is feasible in CTG processes as it is in CTL processes.

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Strategy 6:

Initiate Aggressive Carbon Capture/Sequestration Projects for Coal-Generated Electricity in Kentucky

GOAL By 2025, Kentucky will have evaluated and deployed technologies for carbon management, with use in 50 percent of our coal-based energy applications.

INTRODUCTION

Kentucky must recognize the unique challenges we face in a carbon-constrained world, given our reliance on coal-fired power generation. The threats associated with climate change will require Kentucky to make a concerted effort to control emissions of carbon dioxide, while at the same time recognizing that coal will be a vital component of our energy mix. We must find a way to reduce carbon dioxide emissions and meet our energy needs for the future.

Kentucky's Energy Profile

More than 90 percent of Kentucky's electricity is derived from coal-fired power. And historically, Kentucky has enjoyed some of the lowest electricity rates in the country. This, in turn, has allowed energy-intensive industries to flourish in our commonwealth. As noted previously, our low rates have encouraged Kentuckians to be some of the largest consumers of electricity in the country. Kentucky's per capita consumption of residential electricity is among the highest in the United States (EIA-767, EIA906, 2006).

Electric-power industry carbon dioxide emissions for Kentucky totaled more than 93 million metric tons in 2006, which constitutes 3.8 percent of the U.S. total. Furthermore, we project a need of 7,000 extra megawatts of generation capacity by 2025. There will also be a need for capacity required to replace our aging fleet of plants (Kentucky Public Service Commission, 2005).

In 2004, Kentucky ranked thirteenth nationally in total emissions of carbon dioxide. The top 20 states are listed in Table 9 (EIA, 1990-2004). See Appendices B, C, and D for additional details.

Table 9: Carbon Dioxide Emissions in 2004 from the Top 20 States

Rank	State	Million Metric Tons of CO ₂	Rank	State	Million Metric Tons of CO ₂
1	TX	625.2	11	LA	183.1
2	CA	395.5	12	NC	155.6
3	PA	284.0	13	KY	153.8
4	OH	274.0	14	MO	142.8
5	FL	262.6	15	AL	142.2
6	IL	250.4	16	NJ	133.4
7	IN	237.9	17	VA	130.6
8	NY	212.2	18	TN	125.9
9	MI	192.3	19	WV	114.3
10	GA	185.7	20	WI	112.1

These factors place us in a difficult position as we face the prospects of a carbon-constrained world. And it is indeed the world's problem – one that will require action on a global scale.

Scale of the Problem

Worldwide there are annual emissions of 26 gigatons of carbon dioxide from fossil fuel combustion, with another 9,000 gigatons of carbon dioxide projected to be emitted during the next century. Carbon dioxide is the most abundant anthropogenic (human-caused) greenhouse gas in the atmosphere. In recent years, atmospheric concentrations of carbon dioxide have been rising at a rate of about 0.5 percent per year (EIA, 2007). To stabilize atmospheric carbon dioxide concentrations at a safe level, the 9,000 gigatons of carbon dioxide needs to be lowered to no more than 2,600 to 4,600 gigatons of carbon dioxide (GTSP, 2006).

The Risks

A recent federal government report determined that “climate change is already affecting U.S. water resources, agriculture, land resources, and biodiversity, and will continue to do so.” Furthermore, the impacts are significant, and “alterations are very likely to accelerate in the future, in some cases dramatically.” Examples include a wide range of direct and indirect effects on regional ecosystems such as: increasingly arid conditions that increase the risks of forest fires, changing precipitation trends and outbreaks of pests and invasive species that will affect agricultural production, and widespread modifications to the life cycles of plant and animal species (CCSP, 2008).

Solutions to the Problem

There are a number of factors that can affect total carbon dioxide emissions. For instance, carbon dioxide emissions in the United States during 2006 were 110 million metric tons below their 2005 level of 6,045 million metric tons due to favorable weather conditions; higher energy prices; a decline in carbon intensity of electric power generation that resulted from increased use of natural gas, the least carbon-intensive fossil fuel; and greater reliance on non-fossil energy sources (EIA, 2007).

But there is a growing recognition that the solution lies in a strategy that employs a wide array of technologies. These include: increasing energy efficiency throughout all sectors, increasing electricity generation from sources other than fossil fuels (such as hydroelectric, wind, solar, and nuclear); and separating and capturing the carbon dioxide from industrial and energy-related sources, and transporting it to a storage location for either beneficial reuse or sequestration. Carbon capture and storage has the potential to reduce overall mitigation costs and increase flexibility in achieving greenhouse gas emission reductions (IPCC, 2005).

Pacific Northwest National Laboratory announced on Nov. 17, 2008 that scientists have new evidence suggesting that carbon dioxide can be safely and permanently sequestered in deep, underground basalt rock formations. The new information reveals how water-saturated liquid carbon dioxide can help seal cracks within the rock that otherwise might allow the carbon dioxide to escape. Adequate amounts of molecular water are present in the supercritical carbon dioxide so that the injected carbon dioxide reacts directly with minerals in the basalt. Thus, the carbon dioxide can “self-seal” cracks or fissures that might otherwise allow the carbon dioxide to migrate upward. Though the tests were conducted with basalt, the findings would also be applicable to other geologic formations.

Source: Pacific Northwest National Laboratory, <http://www.pnl.gov/topstory.asp?id=333>

Information is Imperfect

There is a wide discrepancy in carbon dioxide storage capacity estimates. There are preliminary estimates of 11,000 gigatons of carbon dioxide in potential geologic storage capacity worldwide. And many geologic storage locations are also near large groupings of power plants and other industrial facilities. About 95 percent of large U.S. point sources are within 50 miles of candidate carbon dioxide reservoirs (GTSP, 2006).

According to the Intergovernmental Panel on Climate Change (IPCC), it is likely that there is a technical potential of at least 2,000 gigatons of storage capacity in geological formations worldwide. And CCS could contribute 15 percent to 55 percent to the cumulative global carbon dioxide mitigation effort until 2100 (IPCC, 2005).

Kentucky's Challenge

In Kentucky, 93 million metric tons of carbon dioxide are emitted from electric power generation each year.

According to a report from the Kentucky Geological Survey, carbon dioxide sequestration capacity of as much as 28 billion tons total could potentially be found in the deeper and thicker parts of the Devonian shales, which underlay two-thirds of the state (Nuttall et al., 2005). If all carbon dioxide generated could be stored in these formations, then there could potentially be enough storage capacity for over 100 years of Kentucky's power generation.

No Perfect Solutions

There are different types of carbon dioxide capture systems: post-combustion, pre-combustion and oxyfuel combustion. Post-combustion capture requires a solvent to absorb the carbon dioxide from the flue gases, but net power generated is reduced by 29 percent and the costs of the electricity produced increase by as much as 65 percent. The technology required for pre-combustion capture is typically applied to integrated gasification combined cycle plants, and is already widely applied in fertilizer manufacturing and in hydrogen production (EPRI, August 2007). There are no IGCC plants in Kentucky.

Oxyfuel combustion results in high carbon dioxide concentrations in the gas stream and, hence, easier separation of the carbon dioxide. Unfortunately, there is also an increase in energy requirements (20 percent – 30 percent of the net power generated) to separate the oxygen from air (GOEP, 2007).

Retrofitting existing plants with carbon dioxide capture is expected to cost more, and result in lesser plant efficiencies, than for newly built power plants designed for carbon dioxide capture. However, technological advances are occurring in this area. Researchers have developed an innovative approach to speeding up the natural mineralization process which involves permanent storage of carbon dioxide in silicate minerals. Reaction times are being reduced to a matter of minutes, which is a key factor in whether the technology can be applied to retrofits of existing plants. The process

Weyburn Oilfield - Canada

No discussion of carbon capture and sequestration would be complete without a mention of the success story that is the Weyburn Oilfield. Located in Saskatchewan, this oilfield receives injected carbon dioxide, complements of Dakota Gasification's Great Plains Synfuels facility in North Dakota. The oilfield receives, via a 325-km pipeline, 2.7 million cubic meters per day of carbon dioxide. By injecting the carbon dioxide into this seemingly-depleted oilfield, the life of the field has been extended more than 25 years, with another 122 million barrels of crude oil extracted. Soil sampling conducted at the site indicates there is no leakage of carbon dioxide from the reservoir.

Source: U.S. DOE, National Energy Technology Laboratory

involves dissolving the flue gas carbon dioxide in a water slurry of sodium bicarbonate, sodium chloride, and a mineral reactant such as olivine or serpentine, resulting in a precipitate of magnesium carbonate (O'Connor et al.). Researchers at the University of California-Los Angeles have also developed a new class of materials known as zeolitic imidazolate frameworks, or ZIFs, that can be used in high-heat conditions to selectively capture carbon dioxide (Banerjee et al., 2008).

The Sleipner Project - Norway

A private company has successfully demonstrated geologic carbon sequestration. Statoil's wells in the North Sea extract natural gas from a reservoir (the Sleipner field) 3,500 feet below the sea floor. The gas contains excess amounts of carbon dioxide which must be removed in order for the gas to be pipeline quality. Given that the carbon dioxide was already being removed, and facing taxes for carbon dioxide emissions, the company elected to capture, compress, and inject the carbon dioxide into a geologic formation 1,000 feet below the seabed (a location actually more shallow than the gas reservoir). The U.S. Department of Energy has conducted monitoring and verification and recently announced that data show no migration of the carbon dioxide.

Source: U.S. DOE, National Energy Technology Laboratory

Sequestering Carbon Dioxide

Carbon dioxide, once captured using today's technologies, must be compressed to a supercritical state in order to be transported to a suitable storage location. The carbon dioxide is then injected into a geologic reservoir several thousand feet deep. The formations into which the carbon dioxide is injected must be porous, such as deep saline formations, and be covered with an impermeable caprock layer. Oil and gas fields are attractive in that the carbon dioxide, once injected, can force out more oil and gas from seemingly depleted reservoirs. And given that oil and gas were once trapped in these formations, it is reasonable to speculate that the voids left behind can act as a similar storage site for carbon dioxide. There are questions on the long-term viability of this approach as a means of storage that must be addressed (EPRI, 2007).

The costs for a CCS system are significant. A GTSP report predicts costs for coal-fired power plants to be roughly \$20-\$60 per ton of carbon dioxide captured (GTSP, 2006). A National Energy Technology Laboratory (NETL) study of carbon capture retrofits to an existing plant determined the costs to be roughly \$46 per ton with 90 percent carbon dioxide capture (NETL, 2006). Thus, the costs of electricity, once CCS is in place, are expected to increase. The application of capture technology would add about 1.8 to 3.4 cents per kilowatt-hour to the cost of electricity from a pulverized coal power plant (EIA, 2007). For comparison Kentuckians, on average, pay 5.43 cents per kilowatt-hour (EIA, 2007).

Actual costs, of course, are determined by a variety of factors including: the methods used in carbon dioxide



Figure 22: Arizona Public Services' Redhawk power station where algae is harvested and used to produce biodiesel. (Image provided by Raymond Hobbs, APS Senior Engineer, at the Illinois Basin Energy Conference, held March 6, 2008, in Henderson, KY.)

capture; the means of conveyance (pipeline length and dimensions); the source's proximity to geologic sequestration sites; the depth required for geologic sequestration; and any economic gains obtained through enhanced oil and gas recovery or resale of the captured carbon dioxide.

Clearly, the carbon management challenges are significant, and solutions will be costly. It is imperative to mobilize our limited resources to their greatest effect, and to do so as expeditiously as possible.

The Potential of Algae

There is a growing body of work supporting the use of microalgae, the material we typically think of as "pond scum," to take up carbon dioxide emissions from power plant flue gases. There are active projects at MIT and at the Arizona Public Services' (APS) Redhawk power station (Figure 22) where algae is harvested and used to produce biodiesel.

The benefits are significant: high algae growth rates, no need for arable land, no need for potable water, no competition with food crops, and a large variety of natural algae species (50,000+). But perhaps the most important factor is that microalgae can produce roughly 30 times as much oil per unit growth area as typical food crops (Baum, 1994).

The use of algae to mitigate carbon capture has been studied for many years (NREL, 1998). This natural alternative deserves careful and extensive consideration to solve our carbon problem. Researchers at the University of Kentucky's Center for Applied Energy Research (CAER) are moving forward on several fronts to determine the feasibility of algal systems for carbon dioxide capture. The EEC has funded two research projects on algae research and process design.

At the CAER, researchers are examining outcomes from the MIT and APS projects to determine if these processes can succeed in Kentucky. Though algae are amazingly versatile, controlled conditions are nevertheless required in order for algae to thrive at the scale necessary for capturing flue gas carbon dioxide from a power plant.

Light is crucial. When large volumes of algae are growing (in either open ponds or closed, tubular photobioreactors) there are "dark zones" that receive less light, thus inhibiting growth. Salinity, temperature, pH, light intensity, and the strain of algae species are all factors in finding the proper balance to achieve our goal. If not monitored closely, algal growth can progress to the point of taking in too much carbon dioxide as the photosynthesis rate increases, and creating an unsustainable level of dissolved oxygen (Andrews, 2008). Thus, algae sequestration holds a lot of potential, but optimizing the conditions for success can be difficult.

The second project underway at CAER is construction of a demonstration-scale system using a commercially available photobioreactor. This system will be deployed at CAER with the goal of testing algal growth under Kentucky climatic conditions and with a source of carbon dioxide similar to flue gas from an actual power plant. The system will be closely monitored with researchers paying particular attention to any detrimental effects of sulfur dioxide on algal growth. The algae will be dewatered and oils extracted. The dried algae cake (the material remaining after oils are extracted and water is removed) will be examined to determine its nutritional value to determine if this material could be suitable feed for livestock or fisheries.

This program will be ramped up to include further testing of different algal strains, different reactor designs, and different scales of gas streams. If early tests show promise, the EEC and CAER will eventually seek to deploy an algal system at a coal-fired power plant in Kentucky. If successful (80 percent carbon dioxide capture or greater) at a 300 megawatt coal-fired power plant, the system could capture over 1.3 million tons of carbon dioxide per year.

ACHIEVING THE GOAL

By 2025, Kentucky will have evaluated and deployed technologies for carbon management, with use in 50 percent of our coal-based energy applications.

Near-Term Actions (1-3 Years)

1. Kentucky will support the work of the Carbon Management Research Group (CMRG). The CMRG is a consortium of major power companies, the CAER and the EEC. The CMRG will carry out a ten-year, \$24 million program of research to develop and demonstrate cost-effective and practical technologies for reducing and managing carbon dioxide in existing coal-fired electric power plants. There are three main research projects envisioned:
 - Investigation of post-combustion carbon dioxide control technologies using the CAER pilot plant. The CAER will complete a detailed parametric testing for the particular coal that will be fired in a slip-stream field testing site and provide the optimum operational conditions as well as solvent management protocol by 2010.
 - Slip stream investigation of post-combustion carbon dioxide control technologies at a consortium power plant. The CAER will complete a portable slip-stream apparatus fabrication, installation and commissioning by 2010.
 - Development of chemical looping combustion/gasification for solid fuels. The CAER will complete design and fabrication of a bench-scale redox apparatus by 2011.
2. The EEC will examine legal hurdles to successful CCS and recommend legislative solutions to the 2010 General Assembly.
3. The EEC will create a carbon registry to identify source locations and emission levels.
4. Necessary staff positions in the Division of Oil and Gas will be funded to support Kentucky's primacy over the underground injection control permitting program.
5. Working closely with university researchers and industry partners, Kentucky will undertake one large-scale carbon mitigation project to utilize microalgae to capture carbon from flue gases, and then convert the algae to biofuels.
6. Kentucky will support the Consortium for Carbon Storage. With a \$5 million seed grant from the state in 2008, the Kentucky Geological Survey (KGS) has established the Kentucky Consortium for Carbon Storage (KYCCS) to determine the potential for geologic sequestration, enhanced oil and gas recovery and enhanced coal-bed methane recovery using carbon dioxide. The research is being organized into three research projects:
 - Western Kentucky Sequestration,
 - Eastern Kentucky Sequestration, and
 - Enhanced Oil and Gas Recovery.

This project will complement work underway with federal regional carbon sequestration partnerships.

Mid-Term Actions (3-7 years)

1. The CMRG will complete membrane pilot-scale testing by 2014 and a catalytic scrubbing and stripping pilot-scale experiment by 2015.
2. The CMRG will finalize design specifications for a potential slip-stream apparatus by 2009; and complete three site investigations by 2014.
3. The CMRG will finalize design and fabrication of a bench-scale redox apparatus by 2012 and bench-scale testing by 2013.
4. The CMRG will deploy a carbon capture system (post-combustion system, chemical looping, or algae) at a power plant by 2014.
5. The KYCCS will complete well abandonment for the Western Kentucky Deep CO₂ Sequestration Project by 2012.

Long-Term Actions (>7 years)

1. The CMRG will complete its fifth site investigation by 2017.
2. The most technologically feasible and cost-effective CCS methods will begin being implemented by 2018.

IMPLEMENTATION SCHEDULE

Assuming success with capturing and sequestering carbon dioxide from Kentucky power plants and that all new plants are constructed to account for carbon dioxide emissions, the energy mix for the state in the short- to mid-term will be similar to today's situation. Coal will continue to provide significant energy needs in the short term, as we migrate towards a system where our electricity is derived from non-fossil sources such as biomass, wind, solar, and nuclear. Eventually, coal will become a source for liquid and gaseous fuels of the future.

ENVIRONMENTAL BENEFITS & LIMITATIONS

The primary measurement for *Strategy 6* is the amount of carbon dioxide emissions avoided. If Kentucky's power plants can capture 90 percent of the carbon dioxide they now emit, the emissions avoided will total 84 million metric tons. Kentucky will demonstrate the environmental gains to be made by reducing power plant carbon dioxide emissions from 93 million metric tons to 9.3 million metric tons. If we, as a coal state, can reduce our emissions by 55 percent, it will demonstrate Kentucky's leadership. Assuming no changes in the transportation sector (a very conservative assumption), this will result in a 55 percent reduction in carbon dioxide emissions, which is in line with the goals of the U.N. IPCC.

Assuming other nations follow our lead, we can avoid widespread global impacts to natural ecosystems; we can avoid impacts to our food and water supplies; and we can avoid inestimable widespread economic damages to our state and nation.

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Strategy 7:

Examine the Use of Nuclear Power for Electricity Generation in Kentucky

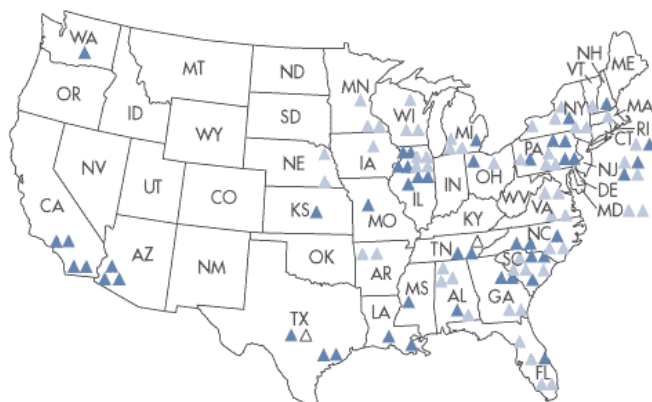
GOAL Nuclear power will be an important and growing component of the nation's energy mix, and Kentucky must decide whether nuclear power will become a significant part of meeting the state's energy needs by 2025.

INTRODUCTION

In a carbon-constrained world, the interdependencies among energy, the environment and the economy will lead to broad sweeping economic transformation in the 21st century. To find solutions that address the climate challenges, use of our abundant natural resources to gain energy security and provide the power needed to drive our economy will require us to pursue a diversified portfolio of energy alternatives. In weighing the benefits and limitations of potential solutions we must be willing to fully assess and understand the societal, technical, and financial trade-offs involved. Nuclear power is one such option that deserves full attention.

Nuclear Power in the World

Nuclear power production has no direct carbon dioxide emissions and is already a significant component of the global energy system. Today there are 443 nuclear power reactors in operation in 31 countries around the world with another 30 in construction. Generating electricity for nearly one billion people, they account for approximately 17 percent of worldwide electricity generation (365 gigawatts).



YEARS OF COMMERCIAL OPERATION	NUMBER OF REACTORS	AVERAGE CAPACITY (MDC)
△ 0-9	2	1134
▲ 10-19	47	1092
▲ 20-29	55	779

Note: There are no commercial reactors in Alaska or Hawaii. Calculated data as of 12/00.
<http://www.nrc.gov/reactors/operating/map-power-reactors.html>

There are 104 commercial nuclear generating units that are fully licensed by the Nuclear Regulatory Commission (NRC) to operate in the United States where they account for approximately 20 percent of our nation's base-load electricity generation (101 gigawatts). Although the United States has the most nuclear capacity of any nation, no new commercial reactor has come on line in this country since May 1996 (EIA, 2008).

The current fleet of nuclear power plants has shown a steady increase in capacity factor over the past two decades. This improved efficiency and reliability has allowed the industry to maintain its approximately 20 percent share of the growing U.S. electricity market without adding any new generating stations. As an industry the median net capacity factor is now over 90 percent (Blake, 2008). In addition to outstanding reliability, the operation of these plants has amassed an outstanding record for safe and environmentally

Figure 23: Power Reactors Operating in the United States

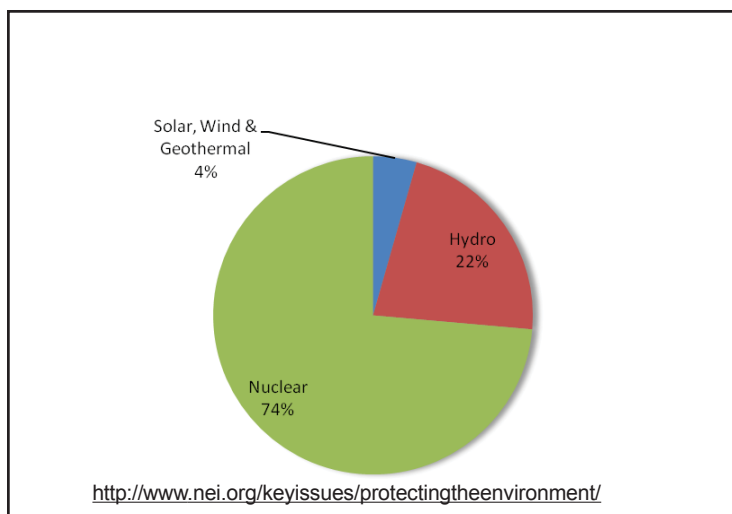


Figure 24: Sources of Emission-Free Electricity 2007

secure operations. Five of the seven states surrounding Kentucky have operating nuclear power plants and much of the eastern half of the U.S. relies on nuclear power as an essential element of their overall electric energy portfolio.

Total U.S. greenhouse gas (GHG) emissions increased from the 1990 baseline of 6,100 million metric tons of carbon dioxide-equivalent to 7,200 million metric tons in 2005. Nuclear-generated electricity avoids almost 700 million metric tons of carbon dioxide per year in the U.S. (over seven times the amount of carbon dioxide emissions from electricity generation in Kentucky). Worldwide nuclear energy avoids on average the emission of more than two billion metric tons of carbon dioxide per year.

Figure 24 illustrates the current sources of carbon dioxide emission-free electricity within the United States (Nuclear Energy Institute, 2008).

Nuclear Power Challenges

To further capitalize and expand on the climate benefits of nuclear power, the potential trade-offs must be well understood. In general, there are four issues that must be addressed in the U.S. in order for nuclear energy growth to be supported economically, publicly and politically.

Safety and Security

The nuclear safety record on an international scale must be maintained while expediting the licensing application/review process for siting and constructing new power plants. The nation's nuclear power plants are among the safest and most secure industrial facilities in the United States. Multiple layers of physical security, together with high levels of operational performance, protect plant workers, the public and the environment. U.S. nuclear plants are well-designed, operated by trained personnel, defended against attack and prepared in the event of an emergency. However, a major nuclear accident anywhere would drastically affect public acceptance and support, based upon historical precedence.

The NRC has implemented stringent federal regulations requiring automated, redundant safety systems, along with the industry's commitment to comprehensive safety procedures to keep nuclear power plants and their communities safe. Operators receive rigorous training and must hold valid federal licenses. All nuclear power plant staff are subject to background and criminal history checks before they are granted access to the plant. Each nuclear power plant has extensive security measures in place to protect the facility from intruders. Since September 11, 2001, the nuclear energy industry has substantially enhanced security at nuclear plants. In addition, every nuclear power plant in the country has a detailed plan for responding in the event of an emergency. Companies test that plan regularly, with the participation of local and state emergency response organizations. In addition, the next

generation of certified reactor designs feature advanced passive safety systems further enhancing the safety of these plants.

Spent Fuel Storage, Transportation, and Disposition

To generate electricity nuclear power plants use uranium oxide fuel (in the form of small ceramic pellets) contained inside metal fuel rods which are grouped into bundles called assemblies. The uranium undergoes the process of fission (the splitting of uranium atoms in a chain reaction) which produces a tremendous amount of heat energy for the amount of material consumed. For example, one pound of uranium produces the same amount of heat energy as approximately 20,000 pounds of coal. Like a coal plant, this energy is used to boil water into steam, which drives a turbine generator to produce electricity. Every 18 to 24 months, the plant is shut down and the oldest fuel assemblies (which have released a considerable amount of energy but have become radioactive as a result of fission) are removed and replaced. All the used nuclear fuel from nuclear power plants is in solid form. A typical 1,000-megawatt nuclear power plant produces enough electricity for 740,000 homes and about 20 metric tons of used uranium fuel each year.

The country's 104 commercial nuclear reactors together produce about 2,000 metric tons of used fuel annually. Today, this used fuel is stored safely at plant sites, either in steel-lined vaults filled with water or steel-and-concrete dry storage containers. The NRC has determined that used fuel could be stored safely at power plant sites for 100 years. Monitoring and maintenance of safety systems ensure public health and safety are protected. Commercial reactor sites have the capability to deploy additional steel-and-concrete containers in on-site facilities. Many of these containers are licensed for both storage on-site and transport to the repository. As an example, if all of the electricity generation in Kentucky were from nuclear power plants, approximately 320 metric tons of used uranium fuel would be produced each year.

Eventually, the U.S. Department of Energy will be required to move the used fuel from plant sites to a centralized federal storage facility or federal geologic repository. Congress and the President approved Yucca Mountain, Nevada, as the site of a federal geologic repository for used nuclear fuel and high-level radioactive defense waste in 2002. In June 2008, the DOE submitted a license application to the NRC for the construction and operation of the repository. The protracted delays in the Yucca Mountain program have prompted considerable interest in a redirection of the nation's used fuel management strategy. Several approaches have been proposed, including additional on-site dry storage, centralized dry storage, and possible recycling of the spent fuel. But all approaches call for increased flexibility in how the government will manage used fuel in the future.

Used nuclear fuel will be transported from nuclear power plants to storage and disposal facilities by rail, truck or barge. The transportation containers used to ship used fuel typically have walls one foot thick, with radiation-shielding materials sandwiched between outer and inner metal shells. To ensure the transportation containers retain their integrity even in the event of an accident, they are designed to withstand a consecutive series of highly destructive tests. In these tests, containers have been crashed into concrete walls at more than 65 miles per hour (mph) and hit by locomotives traveling at 80 mph. Researchers also exposed the containers to fully engulfing fires, dropped massive weights on them and detonated gas tanks next to them. The containers used in these tests survived intact, verifying the integrity of their design. During the past 40 years, more than 3,000 shipments of used fuel have been completed safely in the United States, covering 1.7 million highway, rail and barge miles. Although vehicle accidents have occurred, there has been no release of radioactive materials from the containers or a single injury attributed to the cargo's radioactive nature.

Non-proliferation Safeguards

The increased global use of nuclear energy for peaceful purposes must not increase the risk of nuclear proliferation or terrorism. This will require preventing the further spread of enrichment and reprocessing technologies, avoiding the separation of weapons-usable material, and deployment of more proliferation-resistant technologies with improved safeguards. To combat the threat of proliferation, the international nuclear energy community has put in place rigid, redundant controls to ensure that it can fully account for nuclear materials manufactured for the production of electricity, along with their byproducts. The industry does so through the entire fuel cycle, from the mining of uranium to the safe and secure disposal of used nuclear fuel. These controls include global monitoring by international inspectors and stringent national inspection programs. Commercial reactor fuel poses no risk of proliferation; it cannot be used to make a nuclear weapon. The principal materials of concern in the nuclear-weapons production cycle include highly enriched uranium (HEU) and plutonium. Uranium as mined from the earth poses no risk of proliferation. Before its use in reactors, mined uranium must undergo an enrichment process that concentrates isotopes necessary for power production. This process creates low enriched uranium (LEU) through a lengthy and complex process. It is impossible to create a nuclear weapon from LEU without further enrichment.

Nuclear reactors, once in operation, create plutonium as a byproduct. However, the separation of plutonium contained in used fuel pellets requires complex chemical reprocessing. Like enrichment, reprocessing calls for highly sophisticated chemical processing infrastructure.

Economic Sustainability

Nuclear energy that meets safety, waste disposition, and nonproliferation goals must remain economic and sustainable. Next generation reactors must be selected and developed accordingly. The Energy Policy Act of 2005 (EPAAct) established a number of incentives (discussed below) to encourage development of new nuclear power plants in the United States. Along with these incentives, the inevitability of climate legislation (involving a carbon cap or tax, or requiring carbon capture and sequestration for fossil fuel power plants) make nuclear power even more cost-competitive. The economics of nuclear energy for electricity generation are discussed in greater detail below.

New Reactor Deployment in the United States

In order to simplify licensing of new power plants, the NRC can certify standardized reactor designs for 15 years through the rulemaking process. The NRC review of a design certification application addresses the safety issues of an essentially complete nuclear power plant design, independent of a specific site. Site-specific environmental and safety reviews are conducted once an applicant submits its combined construction and operating license (COL) application. The new generation

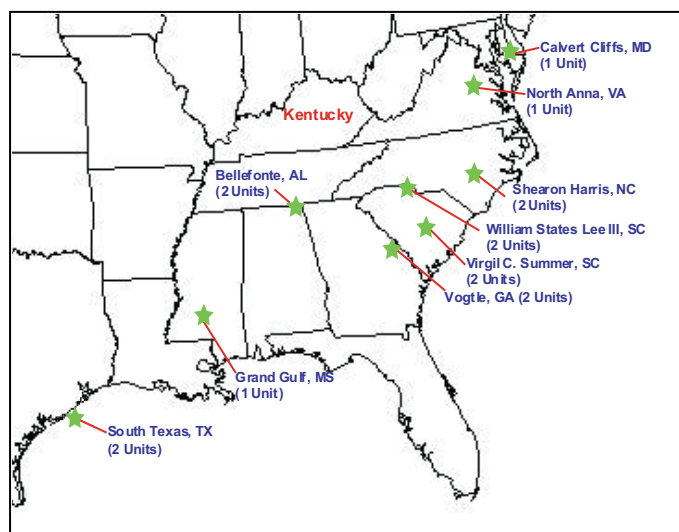


Figure 25: Location of New Power Reactors Sites (COL Applications Submitted to NRC)

Table 10: Next Generation of Reactor Designs Identified for Possible Deployment

Reactor Design	Vendor/ Reactor Type	Capacity (MWe)	NRC Certification Status	Description
AP1000 (Advanced Passive 1000)	Westinghouse/ Pressurized Water Reactor	1117	Certified	The AP1000 is Westinghouse's advanced PWR design. Westinghouse anticipates that operating costs should be below the average of reactors now operating in the United States. The AP1000 includes innovative, passive safety features and a much simplified design intended to reduce the reactor's material and construction costs while improving operational safety. http://www.ap1000.westinghousenuclear.com/
ESBWR (Economically Simplified Boiling Water Reactor)	General Electric/ Boiling Water Reactor	1550	Undergoing Certification	The ESBWR is a new simplified BWR design promoted by General Electric and Hitachi. The ESBWR constitutes an evolution and merging of several earlier designs including the ABWR. The ESBWR, which includes new passive safety features, is intended to cut construction and operating costs significantly from earlier ABWR designs. http://www.gepower.com/prod_serv/products/nuclear_energy/en/new_reactors/esbwr.htm
EPR (Evolutionary Pressurized Water Reactor)	AREVA NP/ Pressurized Water Reactor	1600	Undergoing Certification	AREVA NP announced in early 2005 that it would market its EPR design in the United States and has recently begun design certification activities. The EPR is a conventional, though advanced, PWR in which components have been simplified and considerable emphasis is placed on reactor safety. The proposed size for the EPR has varied over time, but is most frequently placed around 1600 MWe. Earlier designs were as large as 1750 MWe. http://unistarnuclear.com/
ABWR (Advanced Boiling Water Reactor)	General Electric/ Boiling Water Reactor	1371	Certified	Four ABWRs operate in Japan and more are planned there and in Taiwan. While the ABWR design is usually associated in the United States with General Electric, variations on the design have also been built by Toshiba and Hitachi. Hitachi also hopes to associate with General Electric for building additional ABWRs at the South Texas Project. http://www.gepower.com/prod_serv/products/nuclear_energy/en/new_reactors/abwr.htm
US APWR (US Advanced Pressurized Water Reactor)	Mitsubishi/ Pressurized Water Reactor	1700	Undergoing Certification	The US-APWR is a U.S.-marketed variation on APWR design sold in Japan by Mitsubishi Heavy Industries. The 1700 MW US-APWR was only recently (June 2006) announced for the U.S. market. Pre-application design certification activities before the NRC began during July 2006. Mitsubishi submitted a design certification application in March 2008 and hopes to complete the process during 2011. http://www.mhi-r.jp/english/new/sec1/200607031122.html

of reactor designs offers significant advancements in both safety and economics over the existing light-water reactor designs. Table 10 provides a summary of the advanced reactor designs currently under consideration for possible deployment in the United States.

Nine COL applications covering 15 new reactors have been submitted through June 2008 to the NRC for review. Integrated environmental review teams have been assembled for each COL, and the acceptance and scoping phases of these projects has commenced. In addition, up to six more COL applications are expected before the end of the year. Appendix E provides a complete listing of potential new reactor projects identified to the NRC. For each COL application a comprehensive Environmental Impact Statement (EIS) is prepared and public input is sought.

National and State Legislation Affecting the Expansion of Nuclear Power

Energy Policy Act of 2005 (EPAcT)

To meet the national energy policy objectives of energy independence, affordability, and reliability, the Energy Policy Act of 2005 (EPAcT) set forth supply-side policies that are designed to increase the availability and diversity of fuel sources, develop technologies that use fuels more efficiently, and address fuel constraints through the development of alternative energy sources. In addition, the EPAcT also sets demand-side policies to encourage energy conservation. Many of the EPAcT policies and programs are designed to take greater advantage of domestic energy sources and alternative energy sources to displace oil imports.

The EPAcT provides several investment incentives for nuclear power, including:

- Loan guarantees for new nuclear plants.
- Production tax credits (1.8 cent per kilowatt-hour) for new plants.
- Standby support for new reactor licensing delays (investment risk protection).
- Renewal of the Price-Anderson Act insurance indemnification.

Similar incentives were provided for clean coal initiatives, coal-to-liquids development, renewable energy, alternative fuels, energy efficiency programs, and oil and gas development. One important result of this bill and the subsequent Energy Independence and Security Act of 2007 was to provide an investment climate where the risks to financial institutions and equity investors in developing new energy sources (including the next generation of nuclear power plants) was reduced. This enables companies to more easily obtain financing and equity investments needed to develop new domestic energy supplies.

Future Climate Legislation

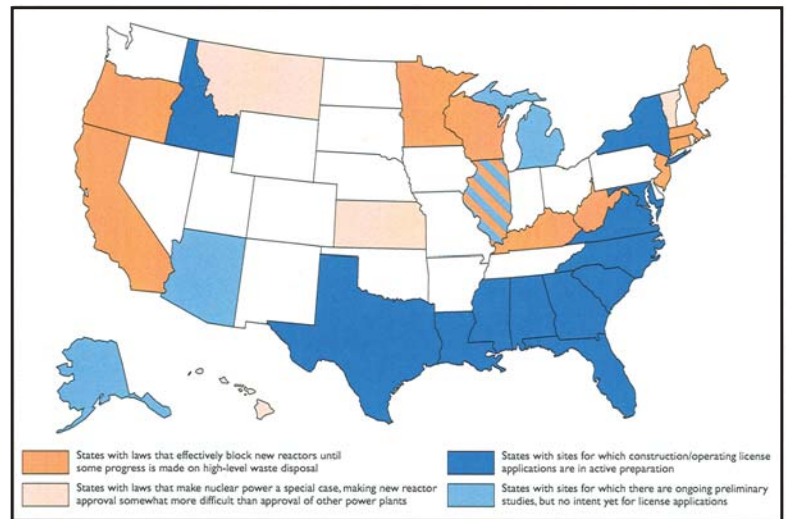
Policy makers are considering various legislative proposals that would impose charges on entities that emit carbon dioxide, the most common greenhouse gas. Such policies could further encourage the use of nuclear power, which emits no such gases, by increasing the cost of generating electricity with competing fossil-fuel technologies.

State Legislation

Even with the likely resurgence in nuclear power, there remain a number of states, including some with significant nuclear power assets, which have passed legislation that would block new reactor projects. Generally these involve developments over which the nuclear community has no control such as the opening of a high-level waste (HLW) repository for spent fuel. Several of these states have recently introduced legislation or considered referendums to repeal or change these laws.

Kentucky has one such law, KRS 278.600-610, on the books. Kentucky law states that a power reactor cannot be certified by the state's Public

Service Commission (PSC) unless a disposal site for HLW either already exists or would be available by the time the plant needs disposal capacity. The PSC also could not certify the project unless it finds that the cost of HLW disposal "is known with reasonable certainty." During the 2008 legislative session, two bills were introduced (SB 156 and HB 542) to "allow construction of such plants provided that the PSC certifies that the facilities' plan for disposal of high level nuclear waste is in conformity with the technology approved by the U.S. Government and that the cost of disposal can be calculated in order that an accurate economic assessment can be completed." These proposed bills did not make it out of committee, but revised versions will likely be reintroduced soon.



<http://www.ans.org/pubs/magazines/nn/docs/2006-11-2.pdf>

Figure 26: State Laws Pertaining to Nuclear Energy

Economics of Nuclear Power

A number of recent studies have been published comparing the life-cycle costs of nuclear power to other sources of electric power, and the potential impacts of climate legislation on these costs. These include:

- Congressional Budget Office (CBO), "Nuclear Power's Role in Generating Electricity." May 2008.
- The Keystone Center, "Nuclear Power Joint Fact Finding," June 2007.
- Congressional Reporting Service Report, "Nuclear Energy Policy," Updated January 2008.
- World Nuclear Organization (WNO) Report, "The Economics of Nuclear Power," May 2008.
- International Energy Agency, "Energy Technology Perspectives, In Support of the G8 Plan of Action, Scenarios and Strategies," 2008.
- Global Energy Technology Strategy Program, "Global Energy Technology Strategy, Addressing Climate Change, Phase 2 Findings from an International Public-Private Sponsored Research Program," May 2007.

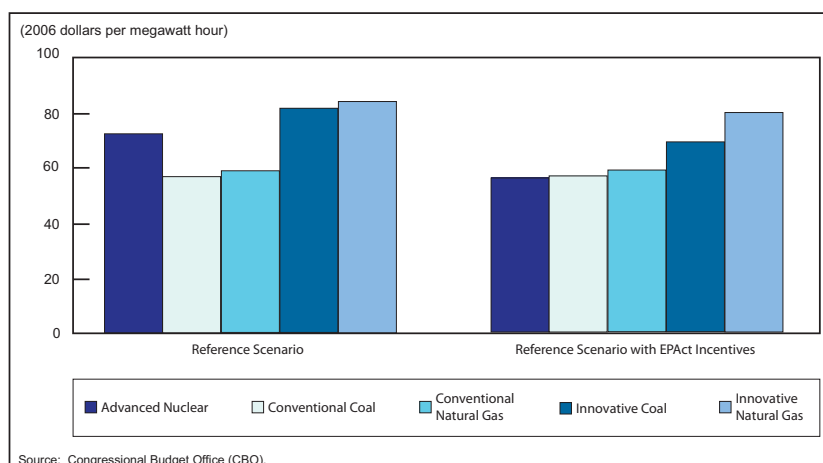
These studies provide a wealth of information relative to the cost of nuclear power, both globally and within the United States. To understand the likelihood of nuclear power expansion within the U.S. one must look at the economics under current conditions, with the incentives provided by the EPAAct of 2005, and under a range of likely scenarios involving capping greenhouse gas emissions.

World-wide nuclear power is cost competitive with other forms of electricity generation, except where there is direct access to low-cost fossil fuels. Capital costs of nuclear power plants are greater than those of traditional fossil-fired plants, with construction costs for nuclear power plants built in the mid-1980s historically ranging from \$2 billion to \$6 billion, averaging more than \$3,000 per kilowatt of electric generating capacity (Holt, 2008). The nuclear industry predicts that new standardized plant designs can be built for considerably less (on the order of \$1,500 per kilowatt), but this assertion has yet to be demonstrated. However, fuel costs (including uranium ore, conversion, fabrication, enrichment and waste fund) are much lower than fuel costs for fossil plants and the costs are much easier to reliably predict.

In order to compare various forms of electricity generation, the concept of levelized life-cycle cost is used. Levelized life-cycle cost is the total cost of a project from construction to retirement and decommissioning, expressed in present value and then spread evenly over the useful output (kilowatt-hours) of the project. It includes the cost of capital and other financing charges as well. In assessing the cost competitiveness of nuclear energy, decommissioning and waste disposal costs must also be included.

From the CBO reference scenario, the levelized cost of nuclear power in the U.S. is 7.2 cents per kilowatt-hour without EPAAct incentives. Adding in the impact of EPAAct production tax credits, loan guarantees, and investment tax credits, the levelized cost of nuclear power in the U.S. is 5.8 cents per kilowatt-hour. The levelized cost of conventional coal power is comparable to nuclear power with the EPAAct incentives, or 5.5 cents per kilowatt-hour. Most studies project the levelized cost of innovative coal power plants (pulverized coal or integrated gasification combined cycle with CCS) to be at least 15 percent greater than nuclear power. The CBO analysis predicts such costs to be 8.2 cents per kilowatt-hour without EPAAct incentives and 6.2 cents per kilowatt-hour with incentives.

One can find a variety of levelized cost estimates. The CBO provides a wide range of estimates, based on variations in future market conditions (fuel costs and construction costs) and variations in future carbon dioxide policy. For nuclear energy the range is 4.8 to 12.1 cents per kilowatt-hour. For conventional coal the range is 4.0 to 12.8 cents per kilowatt-hour. The National Energy Technology Laboratory



<http://www.cbo.gov/ftpdocs/91xx/doc9133/05-02-Nuclear.pdf>

Figure 27: Levelized Cost of Alternative Technologies to Generate Electricity With and Without EPAAct Incentives

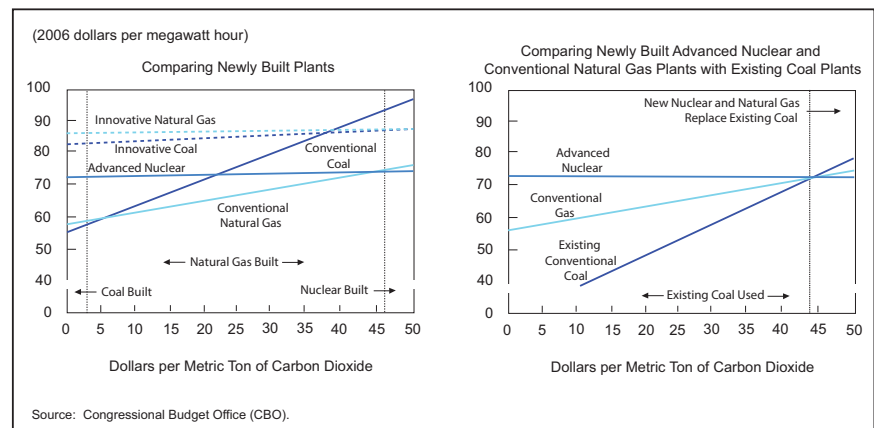
report (NETL, 2007) estimates the levelized costs of innovative coal power (with CCS) to range from 10.6 to 11.7 cents per kilowatt-hour. Figure 27 from the CBO study illustrates the relative costs of various energy generation technologies, both with and without the EAct incentives.

The world's reliance on nuclear power is expected to grow whether or not there are constraints on greenhouse gas emissions. However, in the long run, carbon dioxide charges will increase the competitiveness of nuclear technology and could make it the least expensive source of new base-load capacity. More immediately, EAct incentives by themselves could make advanced nuclear reactors a competitive technology for limited additions to base-load capacity.

Over the past few years, most likely in response to both the prospect of carbon dioxide charges and the incentives offered in EAct, several utilities have begun planning new nuclear projects, which may signal the end of a 30-year hiatus in financing the construction of nuclear power plants. As discussed above, over a dozen utilities have announced their intention to file COL applications for about 30 nuclear plants. Those plants would provide approximately 40,000 megawatts of new capacity. Although the announcements reflect renewed interest in building new nuclear power plants, they do not indicate how much capacity utilities will ultimately build. Completing the revised design and licensing process is expected to cost about \$100 million per plant, about five percent of the anticipated cost for constructing a nuclear plant. Filing a COL application by the end of 2008 may be necessary for those projects to remain eligible for a share of the \$7.5 billion (in nominal dollars) in production tax credits, but filing does not obligate an applicant to build the proposed plant.

Key findings in the CBO's analysis (as illustrated in Figure 28) include:

- In the absence of both carbon dioxide charges (an unlikely scenario) and EAct incentives, conventional fossil-fuel technologies would most likely be the least expensive source of new electricity-generating capacity.
- Carbon dioxide charges of about \$20 per metric ton (for coal) and about \$45 per metric ton (for natural gas) would probably make nuclear generation competitive with conventional fossil fuel technologies as a source of new capacity, even without EAct incentives. At charges below these thresholds, conventional gas technology would probably be a more economic source of base-load capacity than coal technology. Below about \$5 per metric ton, conventional coal technology would probably be the lowest cost source of new capacity.



<http://www.cbo.gov/ftpdocs/91xx/doc9133/05-02-Nuclear.pdf>

Figure 28: Levelized Cost of Alternative Technologies to Generate Electricity Under Carbon Dioxide Charges

- Also at roughly \$45 per metric ton, carbon dioxide charges would probably make nuclear generation competitive with existing coal power plants and could lead utilities to a position to build new nuclear plants that would eventually replace existing coal power plants.
- EPA's incentives would probably make nuclear generation a competitive technology for limited additions to base-load capacity, even in the absence of carbon dioxide charges. However, because some of those incentives are backed by a fixed amount of funding, they would be diluted as the number of nuclear projects increased; consequently, the CBO anticipates that only a few of the 30 plants currently being proposed would be built if utilities did not expect carbon dioxide charges to be imposed.
- Uncertainties about future construction costs or natural gas prices could deter investment in nuclear power. In particular, if construction costs for new nuclear power plants proved to be as high as the average cost of nuclear plants built in the 1970s and 1980s or if natural gas prices fell back to the levels seen in the 1990s, then new nuclear capacity would not be competitive, regardless of the incentives provided by EPA's. Such variations in construction or fuel costs would be less likely to deter investment in new nuclear capacity if investors anticipated a carbon dioxide charge, but those charges would probably have to exceed \$80 per metric ton in order for nuclear technology to remain competitive under either of those circumstances.
- The U.S. Energy Information Administration found that the cost of generating electricity from coal-fired power plants with CCS would exceed the cost of power generated by nuclear power plants by 15 percent.

ACHIEVING THE GOAL

Nuclear power will be an important and growing component of the nation's energy mix, and Kentucky must decide whether nuclear power will become a significant part of meeting the state's energy needs by 2025.

Four major long-term drivers are reshaping the energy industry in the U.S. and in Kentucky. They include:

- Increasing focus on climate change.
- Economic and energy security concerns driving the need for energy reserve and supply diversification.
- Increased electric power intensity of the economy.
- Increasing pressures to revitalize an aging power and fuels infrastructure.

Nuclear power could have an important role in responding to these drivers and could provide the commonwealth with an economically sustainable means to address climate change and power Kentucky's economy, while enabling optimal use of coal resources for advanced coal conversion processes.

Near-Term Actions (1-3 years)

1. Examine legal hurdles to successful inclusion of nuclear power in Kentucky's energy mix and specifically address removal or revision of the ban on new nuclear power plants (K.R.S. 278.600-610).

2. Develop and implement a public engagement plan to gather and address stakeholder feedback and concerns.
3. Promote industry partnerships, where Kentucky utilities are introduced to potential partners in the nuclear industry. A strong team at the EEC could drive this initiative to attract the right mix of potential companies and investors. Introduction of nuclear power in Kentucky would require a unique team with demonstrated experience in the industry and capable of managing large multi-billion dollar projects. Participants would include reactor vendors, engineering, procurement and construction (EPC) contractors, and owners/operators. Consideration could be made in potentially joining or engaging the industrial consortium NuStart Energy (of which Duke and TVA are members).
4. Consider integrating nuclear power into an overall electric power industry transition plan.
5. Conduct a state-wide analysis of carbon dioxide allocations over time and assess economic and transition options under likely climate cap-and-trade scenarios. Recommend policies that minimize the economic impact to rate payers, provides incentives for advanced coal-conversion processes, and exceeds carbon dioxide emission reduction goals.
6. Conduct research to assess the desirability of collocating nuclear power plants with advanced coal conversion plants to assess the effects on reducing carbon dioxide emissions, providing ready access to electricity and/or steam, and possibly using waste heat in the conversion process.
7. Develop criteria and prepare a bank of potential sites for nuclear power plants.

Mid-Term Actions (3-7 years)

1. Consider creating a program of incentives that reduce the risk of capitalizing and financing a new power plant, include assured rates, recovery of a portion of construction costs prior to operation, and tax incentives (refunds, credits, etc.) to attract nuclear power plants to Kentucky.
2. Develop an effective and consistent oversight program that could include expeditious permitting, providing needed infrastructure, and working with local communities and interest groups to ensure the potential concerns are identified early and that involved parties are fully informed of the considerations for siting and operations.
3. Investigate a partnership with the Nuclear Regulatory Commission to understand their licensing process and the interface with the commonwealth's permitting activities.

Long-Term Actions (> 7 years)

1. Work with vocation training institutes in Kentucky to ensure that trained personnel are available to staff the construction and operation of nuclear power plants.
2. Explore with state universities the possibility of adding nuclear engineering, health physics, and radiological science programs to their curriculum.

IMPLEMENTATION SCHEDULE

In order to assess the possible implementation of a nuclear power program by 2025, it is important to understand Kentucky's current electric power industry and recent trends. It is interesting to note that the natural gas generating capacity (currently 23 percent of Kentucky's overall peak capacity

of 20,000 megawatts) built during the early part of the decade is only seeing marginal use for peaking power due to current high natural gas prices.

A moderate investment in nuclear power (8 plants at four sites) could be considered as part of an overall strategy to diversify Kentucky's future electrical energy portfolio, reduce carbon dioxide emissions, and position the state to take advantage of advanced coal conversion opportunities. Kentucky could utilize nuclear power to generate a significant percentage of the state's energy needs, with coal-based and nuclear power for electricity generation being roughly equal. With the likelihood of carbon dioxide penalties, a significant portion of the coal power generation is likely to be new plants with CCS processes implemented.

The assumptions and planning basis behind this case are provided in Figure 29. Assumptions include:

- Annual growth in base-load power is 1.7 percent (which already accounts for efficiency and conservation goals).
- Hydroelectric power stays at the 2006 level.
- Renewable energy rapidly increases to become 10 percent of the portfolio in 2025.
- Natural gas capacity market share remains constant.

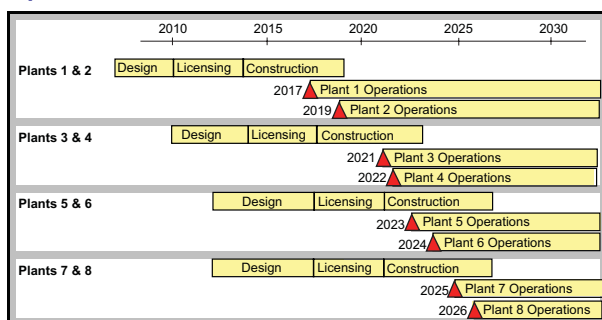
Description:

This scenario implements a moderate investment in nuclear power (8 plants) as part of an overall strategy to diversify Kentucky's future electrical energy portfolio, reduce CO₂ emissions, and position the state to take advantage of Coal-to-Liquid (CTL), Coal-to-Gas (CTG), and/or Biomass opportunities

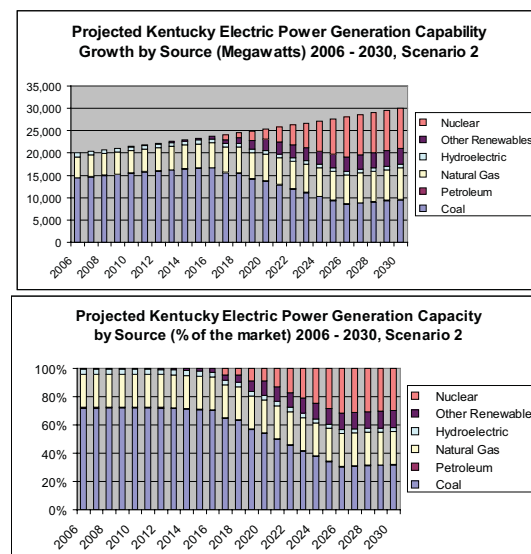
Assumptions & Planning Basis:

- Real growth in base-load power of 1.7%, which already accounts for expected gains in efficiency and conservation goals.
- **Nuclear Power Basis:**
 - Eight - 1117 MW (AP-1000) reactors would be built
 - Four sites would be needed, each site would be licensed to support two plants
 - Start-up is staggered by two years, beginning in 2017 and converts to annual startups in 2021
 - Kentucky Site Bank Evaluation (8/07) used to assess potential sites and possible co-location with a CTL/CTG production plant
- **Hydroelectric power, renewable energy, and natural gas assumptions are the same as Scenario 1.**
- **Coal** is assumed to make up the remainder of power needs and, over time, at least a portion of the conventional coal plants will be replaced and/or upgraded with carbon capture & sequestration (CCS) systems

Implementation Schedule:



Projected Kentucky Energy Portfolio:



Potential Sites:

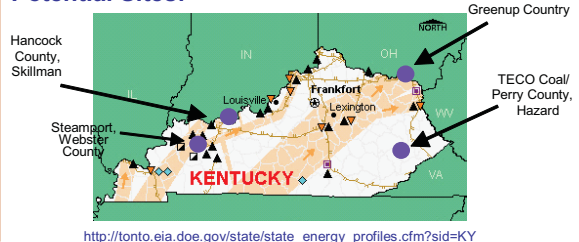


Figure 29: Moderate Investment in Nuclear Power (~30% by 2025)

For this scenario, the use of the AP1000 reactor (1117 megawatts) has been arbitrarily assumed. If alternative (larger) reactor designs are selected the number of plants and sites could be reduced while still meeting the overall capacity needs. Potential sites are provided for illustrative purposes only and have not undergone rigorous evaluation or been subject to the NRC process needed for formal siting. These potential sites were identified using the criteria and analysis provided in the August 2007 Kentucky Site Bank Evaluation for advanced coal conversion processes.

ENVIRONMENTAL BENEFITS & LIMITATIONS

In light of the incentives provided with the EPAct and the potential financial impacts of climate change legislation, nuclear power is an economically viable zero-emission alternative for Kentucky's electric energy mix. The impact on carbon dioxide reductions and their potential economic value are 48 million metric tons of carbon dioxide avoided at \$2.16 million annual economic value assuming carbon dioxide credits of \$45 per metric ton.

In addition to the benefits of reducing Kentucky's carbon dioxide emissions, the addition of nuclear power into the states electric energy mix also supports:

- Competitive power costs – Lowers average cost of power in a carbon constrained world.
- Forward price stability – 60 percent of total costs are fixed.
- Energy Security – Less dependence on imported oil and gas (high reliability).
- Coal conversion processes (coal-to-gas and coal-to-liquids) – Allows the judicious use of carbon dioxide allowances available to Kentucky (trading emissions from power generation to emissions for CTL and CTG development) and possible co-location of plants.
- Enhanced economic development – For the local communities hosting a nuclear power plant thousands of jobs would be created. During the 4-6 year construction period as many as 4000 construction workers would be needed. During operations, 400-700 jobs would be created for each new reactor. Operating life of each reactor is assumed to be 60 years. In addition to the direct workforce benefit, the communities also would benefit through the direct expenditures for goods, services, and labor (CASEnergy Coalition 2008).

Public perception of nuclear power plant safety and the effective disposition of spent nuclear fuel remain two potential concerns that must be effectively addressed. These issues are not unique to Kentucky and are being addressed at a national level. The safety record of existing power plants, including the on-site storage of spent fuel, has been excellent. These issues were explored in detail earlier in this document and should be explicitly covered as part of a public education and engagement program.

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- Nuclear Regulatory Commission – <http://www.nrc.gov/>
- Department of Energy (DOE) – Nuclear Energy Home Page – <http://www.ne.doe.gov/>
- Nuclear Energy Institute - <http://www.nei.org/>

Our Challenge and Our Opportunity

Today, many of the challenges – and indeed the opportunities – we are experiencing in Kentucky and the nation revolve around energy sources, their generation, and their utilization.

This document lays out a comprehensive and holistic energy plan for the commonwealth: it is bold; it is aggressive; it addresses the diverse, myriad driving forces; and it will require considerable courage to adopt and implement.

By making a commitment to reach the proposed goals outlined in the preceding seven strategies, we will maintain the state's per capita energy consumption despite substantial projected growth; increase our energy security overall; reduce our emissions of greenhouse gases; diversify our electricity portfolio; reduce our dependence on imported oil and natural gas; and ensure strong economic growth in the state and increased job opportunities for Kentuckians.

We must launch our efforts by focusing on improving energy efficiency in all sectors of Kentucky's economy and adopting practical conservation practices (*Strategy 1*). Initiatives to improve energy efficiency have little cost compared with the benefits to be gained. Most importantly, these initiatives help us dampen the impact that increasing energy costs have on our lives and economy. Energy efficiency and conservation allow each of us to have a degree of control over our energy and environmental future, and help us to move out of the unenviable ranking of being sixth in per capita energy consumption and seventh in per capita carbon dioxide emissions. Efficiency and conservation are the “cleanest new” sources of energy we can use, and they can come online immediately and at little or no increased cost.

Historically, because of a number of factors including the presence of abundant coal resources, Kentucky has had the fortunate distinction of having relatively low electricity rates compared with most other states. Going forward, we cannot and should not rely on low-cost electricity as a sole driver for economic development. At the same time, we must protect our most economically vulnerable citizens by ensuring access to reasonably priced energy. In today's complex and highly industrialized society, reliable, affordable energy is a right for all Kentuckians.

One overarching goal of this action plan has been to identify and address those actions that can be implemented in sufficient time to help our citizens and businesses prepare for the inevitable changes that will occur in the national and global energy landscape in the years ahead.

Ensuring Viability of Our Coal and Agriculture Economies

In the 21st century, we must take a different approach than those used in the past to protect the 17,000 jobs in the state's mining industry. By following the actions identified in this blueprint, we will closely integrate these jobs and the mining industry, as a whole, to state-based coal-conversion industries.

This strategy ensures the viability of those mining jobs along with thousands of other high-paying skilled jobs that will be created as a result of value-added coal-to-liquid and gaseous fuels industries in the commonwealth (see Figure 30). If we do not take these actions, Kentucky stands to lose one of its most important industries – coal production – as other states that have traditionally relied on

our coal switch to natural gas, nuclear, and renewables as part of their efforts to reduce carbon emissions. We are investing in cleaner coal technologies to reduce greenhouse gas emissions, and at the same time, protect the livelihoods of thousands of Kentuckians dependent on the mining industry.

By developing simultaneously a strong biofuels industry, we not only strengthen our energy security, but we also reinvigorate our domestic agriculture sector and expand opportunities for Kentucky's farmers. The data outlined in *Strategy 3* identifies the potential that Kentucky can be a leader in biofuels production, and can do so in an environmentally sensitive manner. That strategy aims to move Kentucky biofuels production to the next level by developing non-food biomass resources such as algae and switchgrass.

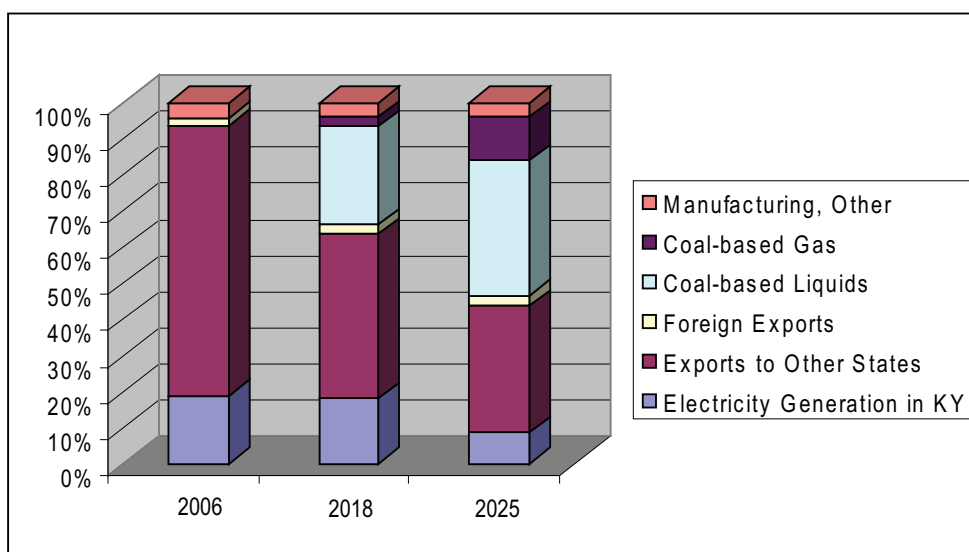


Figure 30: Changing Kentucky Coal Utilization in this Action Plan

Protecting the Environment

For Kentucky to be a national energy leader, we must fully integrate the development of our energy resources with our mission to protect the environment. Therefore, we also focus on strategies that will help us to utilize our coal resources in a cleaner, more efficient manner, and in a way that will help us also meet our goals to increase energy security.

In fully utilizing our biomass, solar, wind, hydro and other renewable energy resources, we not only strengthen our energy security – by diversifying our electricity and transportation fuels portfolios - but we also help the state reduce its carbon dioxide emissions and emissions of other pollutants. Figure 31 projects how the carbon management strategies adopted in this action plan will reduce greenhouse gas emissions and place Kentucky – a coal state – in a leadership position for carbon mitigation. Employing CCS in coal-fired power plants and CTG and CTL processes, along with energy efficiency and conservation and other strategies, we will achieve a 50 percent reduction in carbon dioxide emissions below the projected 2025 Business-As-Usual scenario.

The “carbon penalty” for CTL-derived liquids is included in the estimated carbon dioxide emissions for coal utilization. Nuclear power, which emits no carbon dioxide, could account for 30 percent of Kentucky’s electricity requirements in 2025, and carbon dioxide emissions for biomass utilization although small (representing the “carbon penalty” to produce biofuels) are increased five-fold, consistent with the expansion of the biofuels industry in Kentucky.

Furthermore, if CCS is demonstrated to be highly feasible – through geologic storage and/or biological sequestration – the greenhouse gas reductions would be even more substantial.

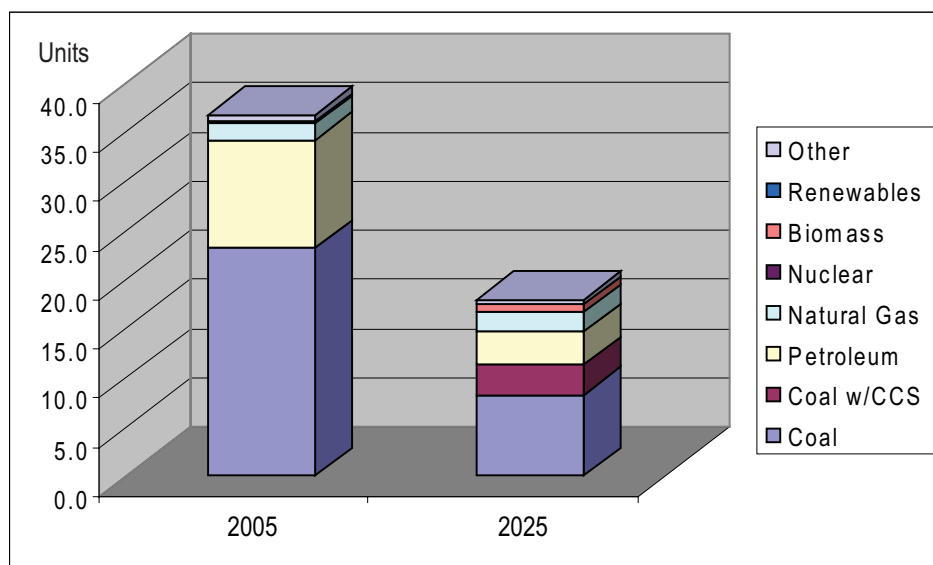


Figure 31: Per Capita Carbon Dioxide Emission Reductions as a Result of Implementing this Energy Strategy

Diversifying Kentucky's Energy Portfolio

The seven strategies, when implemented, will restructure our energy portfolio in such a way that we can use energy in its broadest sense as a tool for economic development. For example, with *Strategies 1, 2* and *3* we aim to bring to the commonwealth “green collar” jobs – jobs that will help rebuild local communities across the state. We must use our innovation and creativity in the years ahead, and as we transform our energy portfolio, it can and must be a force for economic development in the state.

The diversification in Kentucky’s overall energy portfolio is outlined in Figure 32(a), which shows how renewable energy, biomass, and coal utilization with carbon capture and storage all make up a larger percentage of Kentucky’s energy mix in 2025 compared with today. Additionally, given that nuclear energy is likely to be a necessary energy source for base load electricity generation both nationwide and globally in order to address climate change, this source of energy is projected to play a significant role in Kentucky’s energy future as well.

Figure 32(b) clearly shows how implementation of this energy action plan would create a much more diverse electricity portfolio for the commonwealth. Diversifying the sources of energy used to power our homes, schools, businesses, and industries (Figure 32(d)) also has significant energy security, environmental and economic benefits. The same is true of a diversified transportation energy portfolio. Figure 32(c) shows how the transportation sector will be transformed, with a huge reduction on our dependence on oil imports and a greater reliance on domestically produced fuels (both coal-to-liquids and biomass) and electricity generation for plug-in hybrid vehicles.

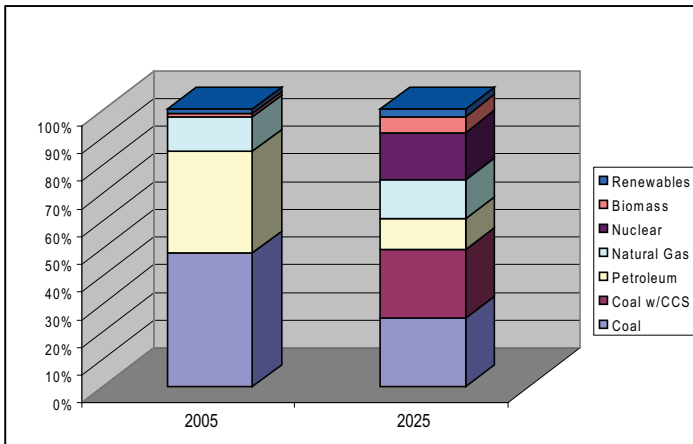


Figure 32(a): Overall Energy Portfolio

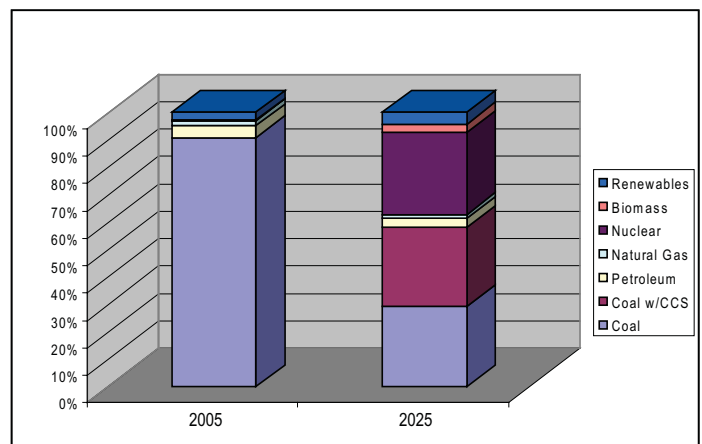


Figure 32(b): Electricity Portfolio

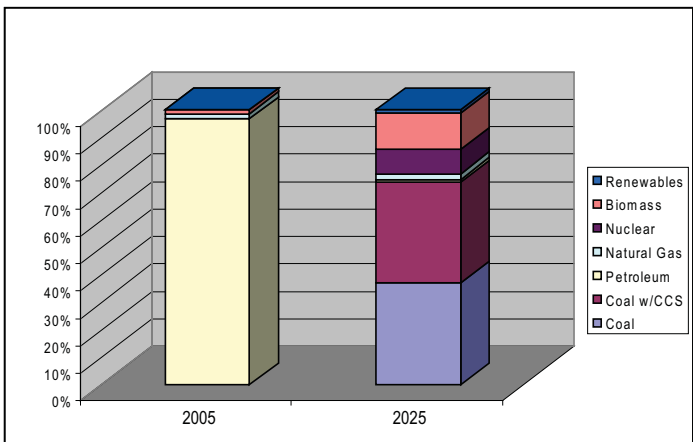


Figure 32(c): Transportation Portfolio

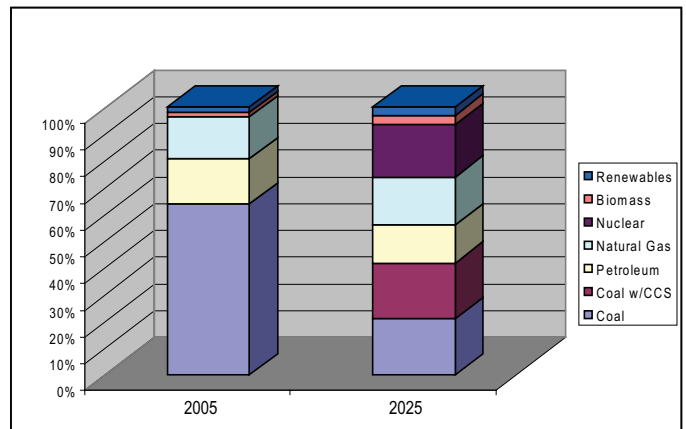


Figure 32(d): Residential, Commercial and Industrial Portfolio

Figure 32: Kentucky Portfolio Today and in 2025

To reiterate, by 2025 we will:

- Maintain current per capita energy use despite major energy growth requirements.
- Fully utilize our renewable energy resources.
- Maintain annual coal production in Kentucky at current levels with coal mining employment at 17,000.
- Produce approximately four billion gallons of liquid fuels from coal (utilizing about 50 million tons of coal annually).
- Produce annually 135 billion cubic feet of syngas from coal (utilizing about nine million tons of coal annually) to augment a robust domestic natural gas supply.
- Provide 30,000-40,000 new Kentucky jobs as a result of a booming diversified energy sector – at least 12,000 directly in our new energy producing sector (3,500 from coal-to-liquids production; 1,800 producing fuels from biomass; 1,700 at coal-to-gas facilities; 4,400 at nuclear plants; and 1,000 at other “green collar,” or renewable energy, industries), and another 20,000-25,000 jobs as a result of the domino effect – jobs which provide indirect

support to the new booming energy industry. The increase assumes sustaining current employment, maintaining annual coal production in Kentucky at current levels, with coal mining employment at 17,000.

- Reduce the net carbon dioxide emissions into the atmosphere by about 50 percent. This will be accomplished by the combination of implementing the carbon capture and sequestration possibilities as facilitated by the research conducted in *Strategy 6*, and building nuclear and renewable generating capacities as described in *Strategy 2* and *Strategy 7*.
- Achieve energy independence for Kentucky from imported oil.
- Ensure Kentucky's economic viability by protecting Kentucky's coal industry against negative impacts of federal carbon management legislation. The mix of nuclear power, renewable energy, coal-to-liquids and coal-to-gas production, and reduced coal-fired electricity generation will enable compliance with federal mandates while maintaining the use of Kentucky's home-grown and most abundant energy resource, coal.

On the other hand, if we fail in our efforts to change our energy directions and simply meander to the business-as-usual scenario in 2025, we will be:

- Using 40 percent more energy.
- Paying 20-50 percent more for each unit of energy purchased.
- Bemoaning our reliance on foreign sources of energy.
- Facing a declining coal industry.
- Captive to limited economic development opportunities.

The strategic choices and directions are clear.

Appendix A

Kentucky's Existing Energy-Related Statutes

Strategy 1: Improve the Energy Efficiency of Kentucky's Homes, Buildings, Industries and Transportation Fleet

Acts					
Year	Chapter	Bill	Section	KRS	Title/description
2007 (s)	1	HB 1	35	12.020	Enumeration of departments, program cabinets, and administrative bodies (Organization)
2007 (s)	1	HB 1	36	12.023	Organizational units and administrative bodies attached to the Governor's office
2007 (s)	1	HB 1	15	42.4582	Local government economic development fund — Schedule of transfers from general fund (Organization)
2008	139	HB 2	21	42.580	Definitions for KRS 42.580 to 42.588. (Bluegrass Turns Green)
2008	139	HB 2	22	42.582	Kentucky Bluegrass Turns Green Program — Purposes — Funding.
2008	139	HB 2	23	42.584	Bluegrass turns green public sector grant fund — Purpose — Eligibility — Payback period — Administrative regulations.
2008	139	HB 2	24	42.586	Bluegrass turns green private sector loan fund — Purpose — Eligibility — Payback period — Interest rate — Administrative regulations
2008	139	HB 2	25	42.588	Administrative regulations — Reports to Governor and Legislative Research Commission.
1998	375	HB 639	1	45.760	Allow for the authorization of an energy savings project or equipment used to reduce energy costs
2005	163	SB 133	1	45A.345	Definitions for KRS 45A.343 to 45A.460
2007(s)	1	HB1	34	45A.625	Procurement strategy for greater use of alternative fuel motor vehicles — Reports.
2002	35	SB 61	1	56.770	Energy savings in state government buildings
2008	139	HB 2	1	56.770	Definitions for KRS 56.770 to 56.784. (Energy Efficiency Program for State Government Buildings)
2007 (s)	1	HB 1	29	56.770	Definitions for KRS 56.770 to 56.784. (Energy Efficiency Program for State Government Buildings)
2008	139	HB 2	2	56.772	Legislative intent — Energy Efficiency Program for State Government Buildings
1998	375	HB 639	5	56.774	Allow for the authorization of an energy savings project or equipment used to reduce energy costs
2002	35	SB 61	2	56.774	Energy savings in state government buildings
2008	139	HB 2	3	56.774	Purpose of program — Engineering analysis — Methods of finance — Documentation of savings.
2008	139	HB 2	4	56.775	Required high-performance building standards — Use of energy-efficiency products.
2007 (s)	1	HB 1	31	56.775	Required high-performance building standards — Use of energy-efficiency products.
2008	139	HB 2	6	56.776	Energy audit training program — Additional programs on energy awareness.
2007 (s)	1	HB 1	30	56.776	Energy audit training program — Additional programs on energy awareness.
2008	139	HB 2	5	56.777	High-Performance Buildings Advisory Committee — Membership — Duties — Administrative regulations — Resource utilization.
2008	139	HB 2	7	56.778	Inclusion of life-cycle energy cost analyses in bids or plans to construct or renovate state-owned buildings.
1996	226		6	56.780	Evaluation for cost-effective energy use and energy efficiency of buildings prior to lease or purchase — Structure of leases.
2008	139	HB 2	8	56.782	Report on use of energy-efficiency measures in state government — Contents
2007 (s)	1	HB 1	33	56.782	Report on use of energy-efficiency measures in state government — Contents
2002	35	SB 61	4	56.783	Energy savings in state government buildings
2008	139	HB 2	9	56.783	Energy efficiency in state government buildings revolving loan fund.
2002	35	SB 61	3	56.784	energy savings in state government buildings
2008	139	HB 2	10	56.784	Guaranteed energy savings performance contracts — Authority for administrative regulations

Strategy 1, continued

Year	Chapter	Acts Bill	Section	KRS	Title/description
2007 (s)	1	HB 1	32	56.784	Guaranteed energy savings performance contracts — Authority for administrative regulations
2007 (s)	1	HB 1	40	56.790	Energy Policy Advisory Council — Membership — Meetings.
1998	375	HB 639	6	58.600	Allow for the authorization of an energy savings project or equipment used to reduce energy costs
1998	375	HB 639	7	58.605	Allow for the authorization of an energy savings project or equipment used to reduce energy costs
1998	375	HB 639	8	58.610	Allow for the authorization of an energy savings project or equipment used to reduce energy costs
2006	231	HB 742	2	96.5407	Home heating assistance fund.
2007 (s)	1	HB 1	17	139.518	Sales or use tax refund on energy-efficiency products used at manufacturing plant.
2008	139	HB 2	12	141.436	Tax credit for installation of energy efficiency products for residential and commercial property — Administrative regulations — Reports.
2008	139	HB 2	13	141.437	Tax credit for construction of ENERGY STAR home or sale of ENERGY STAR manufactured home — Required verification — Reports
2006	152	SB 89	5	143.090	Revenue credited to road fund and Office of Energy Policy
2006	184	HB 299	1	152.710	Legislative findings and determinations.
2007 (s)	1	HB 1	37	152.712	Governor's Office of Energy Policy — Duties — Fees — Funding — Partnerships and cooperative research initiatives.
1998	375	HB 639	9	157.420	Allow for the authorization of an energy savings project or equipment used to reduce energy costs
1998	375	HB 639	10	157.440	Allow for the authorization of an energy savings project or equipment used to reduce energy costs
2008	139	HB 2	17	158.808	Energy technology career track program.
2007 (s)	1	HB 1	54	158.808	Energy technology career track program.
2008	139	HB 2	16	160.325	Mandatory participation in Kentucky Energy Efficiency Program.
2006	137	HB 626	1	278.020	Certificate of convenience and necessity required for construction provision of utility service or of utility — Exceptions — Approval required for acquisition or transfer of ownership — Public hearing on proposed transmission line — Severability of provisions.
1992	102		1	278.183	Surcharge to recover costs of compliance with environmental requirements for coal combustion wastes and by-products — Environmental compliance plan, review and adjustment
2002	365	SB 257	11	278.212	Filing of plans for electrical interconnection with merchant electric generating facility — Costs of upgrading existing grid.
2003	150	HB 524	3	278.216	Site compatibility certificate — Site assessment report — Commission action on application.
2008	139	HB 2	19	278.285	Demand-side management plans — Review and approval of proposed plans and mechanisms — Assignment of costs — Home energy assistance programs.
2006	231	HB 742	1	278.287	Voluntary energy cost assistance fund — Customer contributions — Time of and eligibility for disbursements — Biennial reports — Administration costs
2007 (s)	1	HB 1	49	154.20-420	Science and technology organization — Duties — Funding application process — Negotiation of agreements.
2007 (s)	1	HB 1	1	154.27-010	Definitions for subchapter. (Incentives for Energy Independence Act)
2007 (s)	1	HB 1	3	154.27-030	Application for incentives — Review — Approval.
2007 (s)	1	HB 1	53	164A.250	Student loan forgiveness program for graduates in energy-related fields
1998	375	HB 639	2	45A.345	Allow for the authorization of an energy savings project or equipment used to reduce energy costs
1996	203		1	45A.351	Declaration of public policy on preservation of Commonwealth's natural resources through energy efficiency

Strategy 1, continued

		Acts					
Year	Chapter	Bill	Section	KRS	Title/description		
1998	375	HB 639	3	45A.352	Allow for the authorization of an energy savings project or equipment used to reduce energy costs		
2007	122	HB 145	3	45A.352	Guaranteed energy savings contracts involving local public agencies		
1998	375	HB 639	4	45A.353	Extension of guaranteed energy savings contract — Documentation of savings — Lease -purchase agreements — Exemption from debt limitations		
1998	375	HB 639	4	45A.353	Allow for the authorization of an energy savings project or equipment used to reduce energy costs		
2006	184	HB 299	5	45A.615	Life-cycle cost comparison of heating, ventilation, and air conditioning equipment in state buildings.		
2007 (s)	1	HB 1	34	45A.625	Procurement strategy for greater use of alternative fuel motor vehicles — Reports.		
2008	139	HB 2	27	nc-app	\$50,000,000 in bond funds in fiscal year 2008-2009 for the Bluegrass Turns Green public grant fund for public engineered demand-side management projects.		
2008	139	HB 2	28	nc-app	\$30,000,000 in bond funds in fiscal year 2008-2009 for Bluegrass Turns Green private sector loan fund for private sector engineered demand-side management projects		
2007 (s)	1	HB 1	55	nc-t	Establish a collaborative to develop a plan for the creation of a Center for Renewable Energy Research and Environmental Stewardship which shall develop a comprehensive energy strategy to be submitted to the Legislative Research Commission on or before November 30, 2007.		
2008	139	HB 2	26	nc-cc	Sections 11, 12, and 13 shall apply to taxable periods beginning after December 31, 2008.		
2007 (s)	1	HB 1	51	nc-t	Public utilities, and shall, on or before July 1, 2008, make recommendations to the Legislative Research Commission		

Strategy 2: Increase Kentucky's Use of Renewable Energy

		Acts					
Year	Chapter	Bill	Section	KRS	Title/description		
2007 (s)	1	HB 1	35	12.020	Enumeration of departments, program cabinets, and administrative bodies (Organization)		
2007 (s)	1	HB 1	36	12.023	Organizational units and administrative bodies attached to the Governor's office		
2007 (s)	1	HB 1	15	42.4582	Local government economic development fund — Schedule of transfers from general fund (Organization)		
2007 (s)	1	HB 1	40	56.790	Energy Policy Advisory Council — Membership — Meetings.		
2007 (s)	1	HB 1	10	139.517	Sales tax incentive for alternative fuel, gasification, and renewable energy facilities		
2007 (s)	1	HB 1	27	141.0205	Priority of application and use of tax credits.		
2008	139	HB 2	14	141.0205	Priority of application and use of tax credits.		
2007 (s)	1	HB 1	13	141.310	Withholding of tax from wages paid by employer.		
2007 (s)	1	HB 1	14	141.350	Credit of amount withheld against tax imposed by KRS 141.020 for same taxable year		
2007 (s)	1	HB 1	12	141.421	Tax incentives for alternative fuel, gasification, and renewable energy facilities.		
2007 (s)	1	HB 1	20	141.422	Definitions for KRS 141.422 to 141.425.		
2007 (s)	1	HB 1	44	141.430	Calculation of income tax credit for approved companies — Administrative regulations		
2008	139	HB 2	11	141.435	Definitions for KRS 141.435 to 141.437.		
2006	152	SB 89	5	143.090	Revenue credited to road fund and Office of Energy Policy		
2006	184	HB 299	1	152.710	Legislative findings and determinations.		
2007 (s)	1	HB 1	37	152.712	Governor's Office of Energy Policy — Duties — Fees — Funding — Partnerships and cooperative research initiatives.		

Strategy 2, continued

Acts					Title/description
Year	Chapter	Bill	Section	KRS	
2007 (s)	1	HB 1	54	158.808	Energy technology career track program.
2008	139	HB 2	17	158.808	Energy technology career track program.
2006	137	HB 626	1	278.020	Certificate of convenience and necessity required for construction provision of utility service or of utility — Exceptions — Approval required for acquisition or transfer of ownership — Public hearing on proposed transmission line
1992	102		1	278.183	Surcharge to recover costs of compliance with environmental requirements for coal combustion wastes and by-products — Environmental compliance plan, review and adjustment
2002	365	SB 257	11	278.212	Filing of plans for electrical interconnection with merchant electric generating facility — Costs of upgrading existing grid.
2003	150	HB 524	3	278.216	Site compatibility certificate — Site assessment report — Commission action on application.
2008	138	SB 83	1	278.465	Definitions for KRS 278.465 to 278.468 (Net Metering of Electricity)
2004	193	SB 247	1	278.465	Definitions for KRS 278.465 to 278.468 (Net Metering of Electricity)
2008	138	SB 83	2	278.466	Availability of net metering — Type, expense, and installation of meter — Calculation of electricity billed — Rules applicable to billing — Safety and power quality standards — Transferability of installation
2004	193	SB 247	2	278.466	Availability of net metering — Type, expense, and installation of meter — Calculation of electricity billed — Rules applicable to billing — Safety and power quality standards — Transferability of installation
2008	138	SB 83	3	278.467	Jurisdiction over disputes — Guidelines — Forms — Posting on Web site.
2002	365	SB 257	2	278.702	Kentucky State Board on Electric Generation and Transmission Siting.
2002	365	SB 257	3	278.704	Merchant electric generating facility — Construction certificate — Location of exhaust stack — Setback requirement.
2002	365	SB 257	4	278.706	Application for certificate to construct merchant electric generating facility — Fees — Replacement or repair does not constitute construction.
2002	365	SB 257	5	278.708	Site assessment report — Consultant — Mitigation measures
2002	365	SB 257	6	278.710	Granting or denial of construction certificate — Policy of General Assembly — Transfer of rights and obligation. (consider use of coal per 152.210)
2002	365	SB 257	7	278.712	Local public hearing — Procedure — Parties — Action to vacate or set aside ruling
2002	365	SB 257	8	278.714	Application for certificate to construct nonregulated electric transmission line — Granting or denial — Public hearing — Fee.
2007 (s)	1	HB 1	47	154.20-410	Kentucky alternative fuel and renewable energy fund.
2007 (s)	1	HB 1	48	154.20-415	Kentucky Alternative Fuel and Renewable Energy Fund Program — Purpose.
2007 (s)	1	HB 1	49	154.20-420	Science and technology organization — Duties — Funding application process — Negotiation of agreements.
2007 (s)	1	HB 1	1	154.27-010	Definitions for subchapter. (Incentives for Energy Independence Act)
2007 (s)	1	HB 1	3	154.27-030	Application for incentives — Review — Approval.
2007 (s)	1	HB 1	4	154.27-040	Tax incentive agreement — Required provisions.
2007 (s)	1	HB 1	5	154.27-050	Release of sales tax incentives under tax incentive agreement — Monitoring, tracking, and reporting requirements.
2007 (s)	1	HB 1	9	154.27-090	Advance disbursement of incentives — Computation of maximum disbursement amount — Schedule for disbursement — Repayment
2007 (s)	1	HB 1	53	164A.250	Student loan forgiveness program for graduates in energy-related fields
2007 (s)	1	HB 1	55	nc-t	Establish a collaborative to develop a plan for the creation of a Center for Renewable Energy Research and Environmental Stewardship which shall develop a comprehensive energy strategy to be submitted to the Legislative Research Commission on or before November 30, 2008
2008	139	HB 2	18	nc-t	Governor's Office of Energy Policy to produce a report and recommendations regarding renewables to be presented to the Legislative Research Commission on or before November 30, 2008

Strategy 2, continued

Acts					
<u>Year</u>	<u>Chapter</u>	<u>Bill</u>	<u>Section</u>	<u>KRS</u>	<u>Title/description</u>
2007 (s) 1		HB 1	60	nc-app	\$100,000,000 in bond funds for fiscal year 2007-2008 to the Cabinet for Economic Development, Department of Financial Incentives, Energy Projects Economic Development Bond Pool.
2007 (s) 1		HB 1	50	nc-t	Public Service Commission to examine existing statutes relating to its authority over public utilities and shall, on or before July 1, 2008, make recommendations to the Legislative Research Commission

Strategy 3: Aggressively Grow Kentucky's Production of Biofuels

Acts					
<u>Year</u>	<u>Chapter</u>	<u>Bill</u>	<u>Section</u>	<u>KRS</u>	<u>Title/description</u>
2007 (s) 1		HB 1	35	12.020	Enumeration of departments, program cabinets, and administrative bodies (Organization)
2007 (s) 1		HB 1	36	12.023	Organizational units and administrative bodies attached to the Governor's office
2007 (s) 1		HB 1	15	42.4582	Local government economic development fund — Schedule of transfers from general fund (Organization)
2007 (s) 1		HB 1	40	56.790	Energy Policy Advisory Council — Membership — Meetings.
2007 (s) 1		HB 1	10	139.517	Sales tax incentive for alternative fuel, gasification, and renewable energy facilities
2007 (s) 1		HB 1	27	141.0205	Priority of application and use of tax credits.
2008 139		HB 2	14	141.0205	Priority of application and use of tax credits.
2007 (s) 1		HB 1	13	141.310	Withholding of tax from wages paid by employer.
2007 (s) 1		HB 1	14	141.350	Credit of amount withheld against tax imposed by KRS 141.020 for same taxable year
2007 (s) 1		HB 1	12	141.421	Tax incentives for alternative fuel, gasification, and renewable energy facilities.
2007 (s) 1		HB 1	20	141.422	Definitions for KRS 141.422 to 141.425.
2007 (s) 1		HB 1	21	141.423	Nonrefundable credit for biodiesel producer, biodiesel blender, or renewable diesel producer.
2008 139		HB 2	22	141.424	Biodiesel credit distribution for pass-through entities
2007 (s) 1		HB 1	24	141.4242	Nonrefundable credit for producers of ethanol.
2007 (s) 1		HB 1	23	141.4244	Nonrefundable credit for producers of cellulosic ethanol.
2007 (s) 1		HB 1	25	141.4246	Ethanol or cellulosic ethanol credit distribution for pass-through entities.
2007 (s) 1		HB 1	26	141.4248	Transfer of unused ethanol or cellulosic ethanol tax credit caps established by KRS 141.4242 and 141.4244.
2005 168		HB 272	139	141.425	Authorization for administrative regulations to administer biodiesel credit.
2007 (s) 1		HB 1	44	141.430	Calculation of income tax credit for approved companies — Administrative regulations
2008 139		HB 2	11	141.435	Definitions for KRS 141.435 to 141.437.
2006 152		SB 89	5	143.090	Revenue credited to road fund and Office of Energy Policy
2008 139		HB 2	15	151.720	Powers of authority (KY River Authority)
2006 184		HB 299	1	152.710	Legislative findings and determinations.
2007 (s) 1		HB 1	37	152.712	Governor's Office of Energy Policy — Duties — Fees — Funding — Partnerships and cooperative research initiatives.
2008 139		HB 2	20	152.713	Center for Renewable Energy Research and Environmental Stewardship — Duties — Membership and duties of board of directors.
2007 (s) 1		HB 1	54	158.808	Energy technology career track program.
2008 139		HB 2	17	158.808	Energy technology career track program.
2007 (s) 1		HB 1	45	154.20-400	Definitions for KRS 154.20-400 to 154.20-420.
2007 (s) 1		HB 1	47	154.20-410	Kentucky alternative fuel and renewable energy fund.
2007 (s) 1		HB 1	48	154.20-415	Kentucky Alternative Fuel and Renewable Energy Fund Program — Purpose.

Strategy 3, continued

		Acts				
Year	Chapter	Bill	Section	KRS	Title/description	
2007 (s)	1	HB 1	49	154.20-420	Science and technology organization — Duties — Funding application process — Negotiation of agreements.	
2007 (s)	1	HB 1	1	154.27-010	Definitions for subchapter. (Incentives for Energy Independence Act)	
2007 (s)	1	HB 1	3	154.27-030	Application for incentives — Review — Approval.	
2007 (s)	1	HB 1	4	154.27-040	Tax incentive agreement — Required provisions.	
2007 (s)	1	HB 1	34	45A.625	Procurement strategy for greater use of alternative fuel motor vehicles — Reports.	
2008	139	HB2	14	141.0205	Priority of application and use of tax credits.	
2007 (s)	1	HB1	5	141.422	Definitions for KRS 141.422 to 141.425.	
2007 (s)	1	HB1	24	141.4242	Nonrefundable credit for producers of ethanol.	
2007 (s)	1	HB1	23	141.4244	Nonrefundable credit for producers of cellulosic ethanol.	
2007 (s)	1	HB1	25	141.4246	Ethanol or cellulosic ethanol credit distribution for pass-through entities.	
2007 (s)	1	HB1	26	141.4248	Transfer of unused ethanol or cellulosic ethanol tax credit caps established by KRS 141.4242 and 141.4244.	
2007 (s)	1	HB1	38	152.715	Definitions for KRS 152.710 to 152.725	
2007 (s)	1	HB1	45	154.20-400	Definitions for KRS 154.20-400 to 154.20-420.	
2007 (s)	1	HB 1	5	154.27-050	Release of sales tax incentives under tax incentive agreement — Monitoring, tracking, and reporting requirements.	
2007 (s)	1	HB 1	9	154.27-090	Advance disbursement of incentives — Computation of maximum disbursement amount — Schedule for disbursement — Repayment	
2007 (s)	1	HB 1	53	164A.250	Student loan forgiveness program for graduates in energy-related fields	
2007 (s)	1	HB 1	55	nc-t	Establish a collaborative to develop a plan for the creation of a Center for Renewable Energy Research and Environmental Stewardship which shall develop a comprehensive energy strategy to be submitted to the Legislative Research Commission on or before November 2008.	
1980	210		1	247.900	Legislative purpose.	
2005	85		662	247.910	Definitions.	
2007 (s)	1	HB 1	58	nc-app	\$2,000,000 in fiscal year 2007-2008 from the General Fund to the University of Kentucky to develop the fundamental knowledge, applied science, and engineering necessary to allow industry to rapidly incorporate alternative fuel production technologies into plant design and construction.	

Strategy 4: Develop a Coal-to-Liquids (CTL) Industry in Kentucky to Replace Petroleum-Based Liquids

		Acts				
Year	Chapter	Bill	Section	KRS	Title/description	
2007 (s)	1	HB 1	35	12.020	Enumeration of departments, program cabinets, and administrative bodies (Organization)	
2007 (s)	1	HB 1	36	12.023	Organizational units and administrative bodies attached to the Governor's office	
2007 (s)	1	HB 1	15	42.4582	Local government economic development fund — Schedule of transfers from general fund (Organization)	
2007 (s)	1	HB 1	40	56.790	Energy Policy Advisory Council — Membership — Meetings.	
2007 (s)	1	HB 1	10	139.517	Sales tax incentive for alternative fuel, gasification, and renewable energy facilities	
2007 (s)	1	HB 1	27	141.0205	Priority of application and use of tax credits.	
2008	139	HB 2	14	141.0205	Priority of application and use of tax credits.	
2007 (s)	1	HB 1	18	141.0405	Coal incentive tax credit for electric power generation and alternative fuel or gasification facilities — Procedure for claiming credit — Priority of application.	
2007 (s)	1	HB 1	19	141.0406	Time frame for claiming coal incentive tax credit allowed under KRS 141.0405.	
2006(s)	2	HB1	15	141.041	Tax credit for corporations for installing, modifying or utilizing coal for manufacturing or heating.	

Strategy 4, continued

Acts						Title/description
Year	Chapter	Bill	Section	KRS		
2007 (s)	1	HB 1	13	141.310		Withholding of tax from wages paid by employer.
2007 (s)	1	HB 1	14	141.350		Credit of amount withheld against tax imposed by KRS 141.020 for same taxable year
2007 (s)	1	HB 1	12	141.421		Tax incentives for alternative fuel, gasification, and renewable energy facilities.
2007 (s)	1	HB 1	20	141.422		Definitions for KRS 141.422 to 141.425.
2007 (s)	1	HB 1	28	141.428		Kentucky Clean Coal Incentive Act — Definitions — Tax credit — Administrative regulations
2007 (s)	1	HB 1	44	141.430		Calculation of income tax credit for approved companies — Administrative regulations
2008	139	HB 2	11	141.435		Definitions for KRS 141.435 to 141.437.
2007 (s)	1	HB 1	11	143.024		Tax incentive for purchase or severance of coal used in alternative fuel or gasification facility.
2006	152	SB 89	5	143.090		Revenue credited to road fund and Office of Energy Policy
2006	184	HB 299	1	152.710		Legislative findings and determinations.
2007 (s)	1	HB 1	37	152.712		Governor's Office of Energy Policy — Duties — Fees — Funding — Partnerships and cooperative research initiatives.
2007 (s)	1	HB 1	41	152.714		Funding for preliminary facility site assessments, inventories, and other activities.
2007 (s)	1	HB 1	38	152.715		Definitions for KRS 152.710 to 152.725.
2006	184	HB 299	2	152.715		Definitions for KRS 152.710 to 152.725.
2007 (s)	1	HB 1	39	152.720		Strategy for production of transportation fuels and synthetic natural gas from fossil energy resources and biomass resources.
2006	184	HB 299	3	152.720		Strategy for production of transportation fuels and synthetic natural gas from fossil energy resources and biomass resources.
2006	184	HB 299	4	152.725		Reports of findings and legislative recommendations
2007 (s)	1	HB 1	54	158.808		Energy technology career track program.
2008	139	HB 2	17	158.808		Energy technology career track program.
2007 (s)	1	HB 1	49	154.20-420		Science and technology organization — Duties — Funding application process — Negotiation of agreements.
2007 (s)	1	HB 1	1	154.27-010		Definitions for subchapter. (Incentives for Energy Independence Act)
2006	184	HB 299	1	152.710		Legislative findings and determinations.
2007 (s)	1	HB 1	3	154.27-030		Application for incentives — Review — Approval.
2007 (s)	1	HB 1	4	154.27-040		Tax incentive agreement — Required provisions.
2007 (s)	1	HB 1	5	154.27-050		Release of sales tax incentives under tax incentive agreement — Monitoring, tracking, and reporting requirements.
2007 (s)	1	HB 1	6	154.27-060		Coal severance or processing tax incentives
2007 (s)	1	HB 1	7	154.27-070		Sales and use tax incentives
2007 (s)	1	HB 1	8	154.27-080		Income and limited liability entity tax incentives — Assessment on employees' wages
2007 (s)	1	HB 1	9	154.27-090		Advance disbursement of incentives — Computation of maximum disbursement amount — Schedule for disbursement — Repayment
2007 (s)	1	HB 1	53	164A.250		Student loan forgiveness program for graduates in energy-related fields
2007	30	SB 125	1	224.01-010		Definitions for chapter.
2007	73	SB 196	1	224.01-010		Definitions for chapter.
2007	73	SB 196	2	224.10-225		Facilitation of permits for coal-fired electric generation plants and industrial energy facilities.
2007	73	SB 196	3	224.10-470		Appeals from final orders of the cabinet
2008	57	SB 243	1	224.50-760		Special wastes — Exemptions from KRS 224.46-510 and 224.46-520 — Permit — Notice — Hearing.
2007	30	SB 125	2	224.50-856		Disposal of waste tires — Exceptions — Use of tire-derived fuel — Accumulation of waste tires — Transportation.

Strategy 4, continued

Year	Chapter	Acts Bill	Section	KRS	Title/description
2007 (s)	1	HB 1	58	nc-app	\$2,000,000 in fiscal year 2007-2008 from the General Fund to the University of Kentucky to develop the fundamental knowledge, applied science, and engineering necessary to allow industry to rapidly incorporate alternative fuel production technologies into plant design and construction.

Strategy 5: Implement a Major and Comprehensive Effort to Increase Gas Supplies, Including Coal-to-Gas in Kentucky

Year	Chapter	Acts Bill	Section	KRS	Title/description
2007 (s)	1	HB 1	35	12.020	Enumeration of departments, program cabinets, and administrative bodies (Organization)
2007 (s)	1	HB 1	36	12.023	Organizational units and administrative bodies attached to the Governor's office
2007 (s)	1	HB 1	15	42.4582	Local government economic development fund — Schedule of transfers from general fund (Organization)
2007 (s)	1	HB 1	40	56.790	Energy Policy Advisory Council — Membership — Meetings.
2007 (s)	1	HB 1	10	139.517	Sales tax incentive for alternative fuel, gasification, and renewable energy facilities
2007 (s)	1	HB 1	27	141.0205	Priority of application and use of tax credits.
2008	139	HB 2	14	141.0205	Priority of application and use of tax credits.
2007 (s)	1	HB 1	18	141.0405	Coal incentive tax credit for electric power generation and alternative fuel or gasification facilities — Procedure for claiming credit — Priority of application.
2007 (s)	1	HB 1	19	141.0406	Time frame for claiming coal incentive tax credit allowed under KRS 141.0405.
2006(s)	2	HB 1	15	141.041	Tax credit for corporations for installing, modifying or utilizing coal for manufacturing or heating.
2007 (s)	1	HB 1	13	141.310	Withholding of tax from wages paid by employer.
2007 (s)	1	HB 1	14	141.350	Credit of amount withheld against tax imposed by KRS 141.020 for same taxable year
2007 (s)	1	HB 1	12	141.421	Tax incentives for alternative fuel, gasification, and renewable energy facilities.
2007 (s)	1	HB 1	20	141.422	Definitions for KRS 141.422 to 141.425.
2007 (s)	1	HB 1	28	141.428	Kentucky Clean Coal Incentive Act — Definitions — Tax credit — Administrative regulations
2007 (s)	1	HB 1	44	141.430	Calculation of income tax credit for approved companies — Administrative regulations
2008	139	HB 2	11	141.435	Definitions for KRS 141.435 to 141.437.
2007 (s)	1	HB 1	11	143.024	Tax incentive for purchase or severance of coal used in alternative fuel or gasification facility.
2006	152	SB 89	5	143.090	Revenue credited to road fund and Office of Energy Policy
2006	184	HB 299	1	152.710	Legislative findings and determinations.
2007 (s)	1	HB 1	37	152.712	Governor's Office of Energy Policy — Duties — Fees — Funding — Partnerships and cooperative research initiatives.
2007 (s)	1	HB 1	41	152.714	Funding for preliminary facility site assessments, inventories, and other activities.
2007 (s)	1	HB 1	38	152.715	Definitions for KRS 152.710 to 152.725.
2006	184	HB 299	2	152.715	Definitions for KRS 152.710 to 152.725.
2007 (s)	1	HB 1	39	152.720	Strategy for production of transportation fuels and synthetic natural gas from fossil energy resources and biomass resources.
2006	184	HB 299	3	152.720	Strategy for production of transportation fuels and synthetic natural gas from fossil energy resources and biomass resources.
2006	184	HB 299	4	152.725	Reports of findings and legislative recommendations
2007 (s)	1	HB 1	49	154.20-420	Science and technology organization — Duties — Funding application process — Negotiation of agreements.

Strategy 5, continued

Acts					
Year	Chapter	Bill	Section	KRS	Title/description
2007 (s)	1	HB 1	1	154.27-010	Definitions for subchapter. (Incentives for Energy Independence Act)
2007 (s)	1	HB 1	3	154.27-030	Application for incentives — Review — Approval.
2007 (s)	1	HB 1	4	154.27-040	Tax incentive agreement — Required provisions.
2007 (s)	1	HB 1	5	154.27-050	Release of sales tax incentives under tax incentive agreement — Monitoring, tracking, and reporting requirements.
2007 (s)	1	HB 1	6	154.27-060	Coal severance or processing tax incentives
2007 (s)	1	HB 1	7	154.27-070	Sales and use tax incentives
2007 (s)	1	HB 1	8	154.27-080	Income and limited liability entity tax incentives — Assessment on employees' wages
2007 (s)	1	HB 1	9	154.27-090	Advance disbursement of incentives — Computation of maximum disbursement amount — Schedule for disbursement — Repayment
2007 (s)	1	HB 1	54	158.808	Energy technology career track program.
2008	139	HB 2	17	158.808	Energy technology career track program.
2007 (s)	1	HB 1	53	164A.250	Student loan forgiveness program for graduates in energy-related fields
2006	55	SB 131	1	278.5085	Require the Public Service Commission to approve certain long-term contracts by utilities for synthetic gas from coal
2002	365	SB 257	2	278.702	Kentucky State Board on Electric Generation and Transmission Siting.
2002	365	SB 257	3	278.704	Merchant electric generating facility — Construction certificate — Location of exhaust stack — Setback requirement.
2002	365	SB 257	4	278.706	Application for certificate to construct merchant electric generating facility — Fees — Replacement or repair does not constitute construction.
2002	365	SB 257	5	278.708	Site assessment report — Consultant — Mitigation measures
2002	365	SB 257	6	278.710	Granting or denial of construction certificate — Policy of General Assembly — Transfer of rights and obligation. (consider use of coal per 152.210)
2002	365	SB 257	7	278.712	Local public hearing — Procedure — Parties — Action to vacate or set aside ruling
2002	365	SB 257	8	278.714	Application for certificate to construct nonregulated electric transmission line — Granting or denial — Public hearing — Fee.
2004	65	HB 577	1	349.005	Legislative findings, purpose, and public policy. (relating to coalbed methane development)
2004	65	HB 577	2	349.010	Definitions for chapter.
2004	65	HB 577	3	349.015	Application for permits — Contents, distribution, and filing of plats — Notice to record owners, licensees, and permittees — Information required to accompany plats or exhibits.
2004	65	HB 577	4	349.020	Filing of objections to drilling — Filing of real property interest claims — Issuance of drilling permit — Department to notify Division of Mine Permits of applications to drill — Appeal to review board
2004	65	HB 577	5	349.025	Procedure for plugging and abandoning wells — Request for hearing — Exception — Rights of coal interest holder
2004	65	HB 577	6	349.030	Establishment of rules and procedures for mining through coalbed methane well -
2004	65	HB 577	7	349.035	Application of chapter — Prohibition of waste — Permits required — Notification to state and federal agencies
2004	65	HB 577	8	349.040	Prohibited drilling activities — Filing requirements for permit application — Appeal — Waiver — Filing of maps and plans — Denial of permit
2004	65	HB 577	9	349.045	Voluntary pooling agreements
2004	65	HB 577	10	349.050	Requirements and procedures for stimulating workable coal seam — Contents and construction of agreements to stimulate — Request for hearing — Liability of well operations
2004	65	HB 577	11	349.055	Coalbed Methane Well Review Board established — Board attached to Department of Natural Resources within Environmental and Public Protection Cabinet
2004	65	HB 577	12	349.060	Powers and duties of Coalbed Methane Well Review Board — Promulgation of administrative regulations.

Strategy 5, continued

Acts					Title/description
Year	Chapter	Bill	Section	KRS	
2004	65	HB 577	13	349.065	Authority of Coalbed Methane Well Review Board to hear and rule upon appeals of actions of the Department of Natural Resources — Hearings
2004	65	HB 577	14	349.070	Powers of Coalbed Methane Well Review Board to take actions necessary to prevent waste and protect rights of owners — Objections by holders, lessors, and lessees — Hearings.
2004	65	HB 577	15	349.075	Spacing requirements for vertical and horizontal coalbed methane wells
2004	65	HB 577	16	349.080	Authority of Coalbed Methane Well Review Board to issue pooling orders.
2004	65	HB 577	17	349.085	Duties of person requesting pooling order — Notice to interested persons — Review board to rule on request for pooling order — Contents of pooling order — Rights and financial shares of interested parties — Escrow account
2004	65	HB 577	18	349.090	Civil actions to review orders issued by Coalbed Methane Well Review Board — Procedure — Jurisdiction of Circuit Court.
2004	65	HB 577	19	349.095	Procedure and requirements for drilling coalbed methane well
2004	65	HB 577	20	349.100	Preservation of strings of casing in producing wells.
2004	65	HB 577	21	349.105	Procedure for plugging well — Rights and duties of various parties — Restoration of surface
2004	65	HB 577	22	349.110	Department of Natural Resources to supervise drilling, casing, plugging, and filling of coalbed methane wells — Department to hold hearings and issue orders
2004	65	HB 577	23	349.115	Department of Natural Resources to adopt rules and administrative regulations after notice and hearing — Operators to submit production information annually
2004	65	HB 577	24	349.120	Well operators to execute bonds or blanket bonds in favor of department — Establishment of coalbed methane well plugging fund — Operators' civil and criminal liability
2004	65	HB 577	25	349.125	Permittee to file information for transmittal to the Kentucky Geological Survey — Samples of cuttings — Confidentiality of information — Exception
2004	65	HB 577	26	349.130	Compliance with KRS 353.5901 and 353.595 — Applicants to submit operations and reclamation proposal at time of filing of application
2004	65	HB 577	27	349.135	Expiration of coalbed methane well permit — Extension of permit term.
2004	65	HB 577	28	349.140	Establishment of affirmative defense for willful trespass arising from coalbed methane drilling operations
2004	65	HB 577	29	349.145	Authorization for Department of Natural Resources and Attorney General to bring suit in Circuit Court to restrain violations under this chapter
2004	65	HB 577	30	349.150	Protection of rights in water resources — Responsibility of operators to protect and preserve water supply
2004	65	HB 577	31	349.155	Penalties.
2004	65	HB 577	32	349.160	Construction and interpretation of chapter
2006	160	SB 237	1	353.180	Requirements for plugging abandoned well — Bids — Remedy for possessor of adjacent land or for department.
2008	159	HB 690	1	353.400	Legislative declarations concerning availability and reliability of natural gas supplies — Construction of KRS 353.400 to 353.410.
2008	159	HB 690	2	353.402	Definitions for KRS 353.400 to 353.410.
2008	159	HB 690	3	353.404	Creation of natural gas acquisition authority — Components of agreement — Public agency status — Election of authority formation method.
2008	159	HB 690	4	353.406	Powers of natural gas acquisition authority — Scope of project capacity
2008	159	HB 690	5	353.408	Issuance of bonds for benefit of authority.
2008	159	HB 690	6	353.410	Gas sale contracts by gas acquisition authority
2006	160	SB 237	2	353.590	Application for permit — Fees — Plat — Bond to insure plugging — Schedule — Blanket bonds — Corporate guarantee — Use of forfeited funds — Oil and gas well plugging fund — Wells not included in "water supply well."
2006	160	SB 237	3	353.592	Powers of the department.

Strategy 5, continued

Acts					
Year	Chapter	Bill	Section	KRS	Title/description
2006	160	SB 237	4	353.730	Investigation of abandoned wells — Application — Report — Bond.
2007 (s)	1	HB 1	1	353.750	Definitions for KRS 353.750 to 353.776. (KY Gas Pipeline Authority)
2007 (s)	1	HB1	2	353.750	Definitions for KRS 353.750 to 353.776. (KY Gas Pipeline Authority)
2005	155	HB 225	1	353.750	Definitions for KRS 353.750 to 353.776. (KY Gas Pipeline Authority)
2005	155	HB 225	2	353.752	Kentucky Gas Pipeline Authority established — Membership
2005	155	HB 225	3	353.754	Procedure and organization — Regulations
2005	155	HB 225	4	353.756	Purpose of authority — Powers of the authority
2005	155	HB 225	5	353.758	Issuance of revenue bonds — Proceeds of bonds — Notes or temporary bonds
2005	155	HB 225	6	353.760	Bonds of authority not debts of Commonwealth
2005	155	HB 225	7	353.762	Discretionary securing of bonds by trust indentures
2005	155	HB 225	8	353.764	Enforcement of rights by bond holder or trustee of trust indenture
2005	155	HB 225	9	353.766	Status of authority bonds as securities.
2005	155	HB 225	10	353.768	Issuance of revenue refunding bonds
2005	155	HB 225	11	353.770	Treatment of moneys received
2005	155	HB 225	12	353.772	Exemptions from taxation.
2005	155	HB 225	13	353.774	KRS 45A.045 not applicable to authority projects
2005	155	HB 225	14	353.776	Reporting of activities
2007	30	SB 125	1	224.01-010	Definitions for chapter.
2007	73	SB 196	1	224.01-010	Definitions for chapter.
2007	73	SB 196	2	224.10-225	Facilitation of permits for coal-fired electric generation plants and industrial energy facilities.
2007	73	SB 196	3	224.10-470	Appeals from final orders of the cabinet
2008	57	SB 243	1	224.50-760	Special wastes — Exemptions from KRS 224.46-510 and 224.46-520 — Permit — Notice — Hearing.
2007	30	SB 125	2	224.50-856	Disposal of waste tires — Exceptions — Use of tire-derived fuel — Accumulation of waste tires — Transportation.
2006	1	HB 283	1	nc-app	From natural gas severance tax receipts for the General Fund, appropriate \$10,000,000 in fiscal year 2005-2006 to be used to provide heating assistance through the crisis component of the Low Income Home Energy Assistance Program.

Strategy 6: Initiate Aggressive Carbon Capture/Sequestration Projects for Coal-Generated Electricity in Kentucky

Acts					
Year	Chapter	Bill	Section	KRS	Title/description
2007 (s)	1	HB 1	35	12.020	Enumeration of departments, program cabinets, and administrative bodies (Organization)
2007 (s)	1	HB 1	36	12.023	Organizational units and administrative bodies attached to the Governor's office
2007 (s)	1	HB 1	15	42.4582	Local government economic development fund — Schedule of transfers from general fund (Organization)
2007 (s)	1	HB 1	40	56.790	Energy Policy Advisory Council — Membership — Meetings.
2006	152	SB 89	5	143.090	Revenue credited to road fund and Office of Energy Policy
2007 (s)	1	HB 1	37	152.712	Governor's Office of Energy Policy — Duties — Fees — Funding — Partnerships and cooperative research initiatives.
2007 (s)	1	HB1	37	152.712	Description of Governor's Office of Energy Policy
2007 (s)	1	HB 1	54	158.808	Energy technology career track program.
2008	139	HB 2	17	158.808	Energy technology career track program.
2007 (s)	1	HB 1	49	154.20-420	Science and technology organization — Duties — Funding application process — Negotiation of agreements.

Strategy 6, continued

Acts					
Year	Chapter	Bill	Section	KRS	Title/description
2007 (s)	1	HB 1	1	154.27-010	Definitions for subchapter. (Incentives for Energy Independence Act)
2007 (s)	1	HB 1	3	154.27-030	Application for incentives — Review — Approval.
2007 (s)	1	HB 1	53	164A.250	Student loan forgiveness program for graduates in energy-related fields
1998	470	SB 300	1	224.20-125	Prohibit the Natural Resources and Environmental Protection Cabinet from promulgating administrative regulations or imposing permit conditions to control greenhouse gas emissions as provided for by the Kyoto Protocol.

Strategy 7: Examine the Use of Nuclear Power for Electricity Generation in Kentucky

Acts					
Year	Chapter	Bill	Section	KRS	Title/description
2007 (s)	1	HB 1	35	12.020	Enumeration of departments, program cabinets, and administrative bodies (Organization)
2007 (s)	1	HB 1	36	12.023	Organizational units and administrative bodies attached to the Governor's office
2007 (s)	1	HB 1	15	42.4582	Local government economic development fund — Schedule of transfers from general fund (Organization)
2005	99	SB 47	106	48.850	Appropriations for capital construction, operating budget, regulating, and monitoring of nuclear waste disposal site.
2007 (s)	1	HB 1	40	56.790	Energy Policy Advisory Council — Membership — Meetings.
2006	152	SB 89	5	143.090	Revenue credited to road fund and Office of Energy Policy
1982	76		1	152.200	152.200 Definitions for KRS 152.200 to 152.250. (NOT YET EFFECTIVE)
1960	113		1	152.200	152.200 Definitions for KRS 152.200 to 152.250.
1982	76		4	152.210	Southern Interstate Nuclear Compact — Kentucky as party — Substance (NOT YET EFFECTIVE)
2007 (s)	1	HB 1	37	152.712	Governor's Office of Energy Policy — Duties — Fees — Funding — Partnerships and cooperative research initiatives.
2007 (s)	1	HB 1	37	152.712	Description of Governor's Office of Energy Policy
2007 (s)	1	HB 1	54	158.808	Energy technology career track program.
2008	139	HB 2	17	158.808	Energy technology career track program.
1978	279		1	211.852	Prerequisites to approval of nuclear waste disposal facility — Procedure — Exception (CHFS)
1980	139		1	211.854	Monitoring radiation in discharges into rivers — Report of violations to United States attorney
1996	42		2	211.862	Definitions for KRS 211.861 to 211.869. (low level radioactive waste)
1980	17		1	211.892	Legislative finding (nuclear waste sites)
1980	17		2	211.894	Conditions for relinquishing of ownership of low-level nuclear waste disposal site — Commonwealth policy as to sites or facilities — Contracts or agreements with federal government
1980	17		3	211.896	Conditions for reopening of closed facility (nuclear waste)
1980	17		4	211.898	Stabilization and decommissioning of facility owned by Commonwealth.
2006	137	HB 626	1	278.020	Certificate of convenience and necessity required for construction provision of utility service or of utility — Exceptions — Approval required for acquisition or transfer of ownership — Public hearing on proposed transmission line.
2003	84	SB 146	1	278.042	Service adequacy and safety standards for electric utilities—National Electrical Safety Code.
1992	102		1	278.183	Surcharge to recover costs of compliance with environmental requirements for coal combustion wastes and by-products — Environmental compliance plan, review and adjustment

Strategy 7, continued

Acts					
Year	Chapter	Bill	Section	KRS	Title/description
2002	365	SB 257	11	278.212	Filing of plans for electrical interconnection with merchant electric generating facility — Costs of upgrading existing grid.
2003	150	HB 524	3	278.216	Site compatibility certificate — Site assessment report — Commission action on application.
1984	15		1	278.600	Definitions (Nuclear facility)
1984	15		2	278.605	Construction prohibited until means for disposal of high level nuclear waste approved by United States government
1984	15		3	278.610	Requirements for certification of nuclear power facility
2002	365	SB 257	2	278.702	Kentucky State Board on Electric Generation and Transmission Siting.
2002	365	SB 257	3	278.704	Merchant electric generating facility — Construction certificate — Location of exhaust stack — Setback requirement.
2007 (s)	1	HB 1	57	nc-app	\$5,000,000 in fiscal year 2007-2008 from the General Fund to the Governor's Office of Energy Policy for the purpose of entering into a memorandum of agreement with the Kentucky Geological Survey at the University of Kentucky
2007 (s)	1	HB 1	52	nc-t	Governor's Office of Energy Policy, the University of Kentucky Center for Applied Energy Research, the Geological Survey at the University of Kentucky, the Public Service Commission, and the Environmental and Public Protection Cabinet
1982	76		3	152.212	Appointment of Kentucky board members — Terms (NOT YET EFFECTIVE; SEE NOTE FOLLOWING TEXT).
2002	365	SB 257	4	278.706	Application for certificate to construct merchant electric generating facility — Fees — Replacement or repair does not constitute construction.
2002	365	SB 257	5	278.708	Site assessment report — Consultant — Mitigation measures
2002	365	SB 257	6	278.710	Granting or denial of construction certificate — Policy of General Assembly — Transfer of rights and obligation. (consider use of coal per 152.210)
2002	365	SB 257	7	278.712	Local public hearing — Procedure — Parties — Action to vacate or set aside ruling
2002	365	SB 257	8	278.714	Application for certificate to construct nonregulated electric transmission line — Granting or denial — Public hearing — Fee.
2007 (s)	1	HB 1	49	154.20-420	Science and technology organization — Duties — Funding application process — Negotiation of agreements.
2007 (s)	1	HB 1	1	154.27-010	Definitions for subchapter. (Incentives for Energy Independence Act)
2007 (s)	1	HB 1	3	154.27-030	Application for incentives — Review — Approval.
2007 (s)	1	HB 1	53	164A.250	Student loan forgiveness program for graduates in energy-related fields

Other Energy Legislation Not Specific to Strategies

Acts					
Year	Chapter	Bill	Section	KRS	Title/description
2007 (s)	1	HB 1	16	42.4585	Transfers from local government economic development fund to local government economic assistance fund — Schedule of transfers.
2007 (s)	1	HB 1	46	154.20-405	Powers of cabinet under KRS 154.20-400 to 154.20-420.
2007 (s)	1	HB 1	2	154.27-020	Short title — Legislative findings — Purpose of subchapter— Incentives.
2000	321	HB 806	1	154.22-010	Definitions for KRS 154.22-010 to 154.22-080.
2000	321	HB 806	2	154.22-020	Legislative findings
2000	321	HB 806	3	154.22-040	Certification of qualified counties — Loss of certification — Coal producing counties qualified for electric generation — Selection of eligible companies under Rural Economic Development Assistance Program — Limitation of applicability for nonprofit corporations with handicapped and sheltered workers
2000	321	HB 806	5	154.28-010	Definitions for KRS 154.28-010 to 154.28-100.
2000	321	HB 806	6	154.28-015	Legislative findings.

Other Energy Legislation Not Specific to Strategies, continued

Acts					
Year	Chapter	Bill	Section	KRS	Title/description
2000	321	HB 806	7	154.28-080	Standards for approval of eligible companies and projects — Authorizing resolution.
2000	321	HB 806	8	154.28-090	Agreements between authority and approved companies — Time limits — Tax credits and assessments as inducements for approved companies — Assignment of agreement — Documentation of expenditures — Suspension of inducements — Authority's remedies in case of failure to comply — Activation date — Duties of Department of Revenue
2007 (s)	1	HB 1	42	224.10-100	Powers and duties of cabinet
2007 (s)	1	HB 1	43	224.10-103	Powers and duties of Environmental and Public Protection Cabinet.
2007	73	SB 196	4	278.700	Definitions for KRS 278.700 to 278.716. (Electric Generation and Transmission Siting)
2006	138	HB 665	1	278.700	Definitions for KRS 278.700 to 278.716. (relating to coal-based production of hydrogen and electricity with minimum emissions; define a demonstration project for coal-based production of hydrogen and electricity as a qualifying electric generating facility
2006	137	HB 626	2	278.714	Application for certificate to construct nonregulated electric transmission line — Granting or denial — Public hearing — Fee.
2002	365	SB 257	9	278.716	278.716 Siting fund.
2006	114	HB 568	1	279.020	Who may incorporate. (Electric Cooperatives)
2006	114	HB 568	2	279.110	General powers of rural electric cooperative corporations.
2006	4	HB 275	1	279.120	Persons with whom corporation may do business — Conditions for acquisition of new base load generating facility
2007 (s)	1	HB 1	59	nc-app	\$300,000 in fiscal year 2007-2008 from the General Fund to the Kentucky Department of Education to support the energy technology career track program
2007 (s)	1	HB 1	61	nc-ec	Act takes effect upon its passage and approval by the Governor or upon its otherwise becoming a law.
2006	1	HB 283	2	nc-ec	Passage and approval by the Governor or upon its otherwise becoming a law.
2007 (s)	1	HB 1	6	nc-t	This Act shall be known as the Kentucky Energy Security National Leadership Act
2004	12	SB 118	1	279.120	Persons with whom corporation may do business — Conditions for acquisition of new base load generating facility.
2004	12	SB 118	2	279.125	Transmission, distribution or sale of energy to municipally owned electric utility — Exceptions
2008	104	SB 69	1	224.46-580	Development of statewide programs — Responsibilities of cabinet — Hazardous waste assessment — Waiver — Hazardous waste management fund — Pollution prevention fund — Response actions to release of waste — Post-closure site integrity

t - temporary

nc - not codified

ec - emergency clause or specified effective date

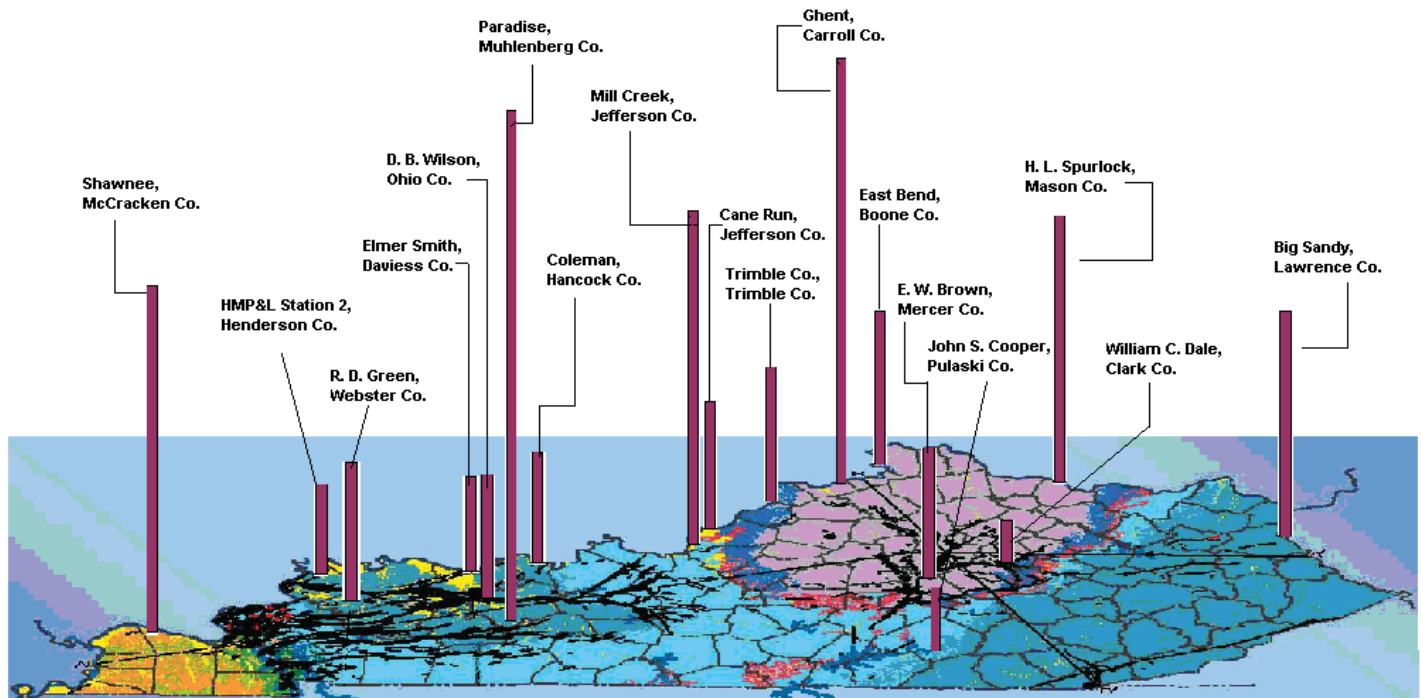
cc - construction clause

app - appropriation

Appendix B

Kentucky's Carbon Landscape

Power Plants with Greater than 1 Million Tons of CO₂ Emitted in 2006



Emissions data from the U.S. Environmental Protection Agency; Clean Air Markets Division;
2006 Data in millions of tons of CO₂.

Slanted map of Kentucky provided courtesy of the Kentucky Geological Survey.

Appendix C

Electric Power Carbon Dioxide Emissions – 2006

Facility Name	Year	CO ₂ Tons	County
Shawnee	2006	10,527,301.8	McCracken
HMP&L Station 2	2006	2,728,131.9	Henderson
Robert Reid	2006	164,904.4	Webster
Henderson I	2006	12,520.0	Henderson
R D Green	2006	4,215,730.8	Webster
Green River	2006	752,635.3	Muhlenberg
Elmer Smith	2006	2,846,614.6	Daviess
D B Wilson	2006	3,758,818.5	Ohio
Paradise	2006	15,497,610.3	Muhlenberg
Coleman	2006	3,404,056.9	Hancock
Mill Creek	2006	10,089,534.6	Jefferson
Cane Run	2006	3,853,534.6	Jefferson
Paddy's Run	2006	53,108.6	Jefferson
Bluegrass Generation Company, LLC	2006	9,703.6	Oldham
Trimble County	2006	4,107,396.6	Trimble
Ghent	2006	12,933,317.7	Carroll
East Bend	2006	4,671,335.6	Boone
Tyrone	2006	331,772.1	Woodford
E W Brown	2006	3,978,892.1	Mercer
John S. Cooper	2006	1,969,271.4	Pulaski
William C. Dale	2006	1,253,741.9	Clark
H L Spurlock	2006	8,105,061.5	Mason
Smith Generating Facility	2006	177,207.7	Clark
Riverside Generating Company	2006	16,765.6	Lawrence
Big Sandy	2006	6,830,275.3	Lawrence
		102,289,243.2	

Source: U.S. Environmental Protection Agency, Clean Air Markets Division

Appendix D

National Carbon Dioxide Emissions by State for 2000

Data from 2000; CO₂ in MMT from EIA; Population from Census.gov

State ID	State	Population	CO ₂ MMT	CO ₂ MT	CO ₂ MT Per Capita	Rank Per Capita
WY	Wyoming	493,985	62.4	62,417,918	126.36	1
ND	North Dakota	641,236	51.1	51,109,910	79.71	2
WV	West Virginia	1,807,050	113.0	113,008,183	62.54	3
AK	Alaska	627,462	38.8	38,797,930	61.83	4
LA	Louisiana	4,469,044	192.1	192,103,115	42.99	5
IN	Indiana	6,091,735	241.4	241,439,240	39.63	6
KY	Kentucky	4,049,049	151.1	151,101,407	37.32	7
MT	Montana	903,329	31.3	31,312,890	34.66	8
NM	New Mexico	1,820,861	59.1	59,081,646	32.45	9
AL	Alabama	4,451,887	140.0	139,950,624	31.44	10
TX	Texas	20,948,843	654.1	654,106,799	31.22	11
OK	Oklahoma	3,454,058	100.4	100,399,407	29.07	12
UT	Utah	2,244,431	65.1	65,097,357	29.00	13
KS	Kansas	2,692,890	76.7	76,711,240	28.49	14
IA	Iowa	2,928,246	80.1	80,078,322	27.35	15
AR	Arkansas	2,678,397	65.1	65,082,308	24.30	16
NE	Nebraska	1,713,322	41.4	41,435,628	24.18	17
OH	Ohio	11,364,143	267.3	267,333,876	23.52	18
PA	Pennsylvania	12,285,564	279.4	279,416,304	22.74	19
NV	Nevada	2,018,494	45.4	45,413,109	22.50	20
MO	Missouri	5,606,140	125.7	125,658,287	22.41	21
TN	Tennessee	5,703,415	124.6	124,595,539	21.85	22
MS	Mississippi	2,848,424	60.5	60,467,286	21.23	23
DE	Delaware	786,463	16.6	16,647,284	21.17	24
WI	Wisconsin	5,374,399	111.9	111,907,039	20.82	25
GA	Georgia	8,230,919	169.2	169,205,493	20.56	26
MN	Minnesota	4,934,185	99.0	98,972,005	20.06	27
MI	Michigan	9,955,417	197.5	197,527,763	19.84	28
CO	Colorado	4,328,252	85.2	85,177,021	19.68	29
SC	South Carolina	4,023,628	78.0	78,007,876	19.39	30
IL	Illinois	12,439,219	239.4	239,406,939	19.25	31
SD	South Dakota	755,713	14.2	14,172,848	18.75	32
NC	North Carolina	8,079,777	150.9	150,941,212	18.68	33
ME	Maine	1,277,225	22.7	22,723,814	17.79	34
VA	Virginia	7,104,992	123.7	123,671,845	17.41	35
AZ	Arizona	5,167,260	86.6	86,638,109	16.77	36
HI	Hawaii	1,211,586	18.9	18,922,402	15.62	37
FL	Florida	16,049,316	242.7	242,689,527	15.12	38
NH	New Hampshire	1,240,442	18.4	18,370,288	14.81	39
NJ	New Jersey	8,431,951	124.2	124,150,593	14.72	40
MD	Maryland	5,310,916	77.9	77,945,086	14.68	41
WA	Washington	5,911,652	83.2	83,218,235	14.08	42
MA	Massachusetts	6,363,190	83.8	83,781,608	13.17	43
CT	Connecticut	3,411,990	44.2	44,159,148	12.94	44
OR	Oregon	3,431,096	41.6	41,587,666	12.12	45
ID	Idaho	1,299,578	15.5	15,490,263	11.92	46
NY	New York	18,996,571	218.3	218,285,691	11.49	47
CA	California	34,004,051	381.8	381,784,443	11.23	48
VT	Vermont	609,909	6.7	6,731,930	11.04	49
RI	Rhode Island	1,050,807	11.5	11,467,447	10.91	50
DC	District of Columbia	571,799	4.3	4,294,292	7.51	51

Release Date: October 2008

http://www.eia.doe.gov/oiaf/1605/ggrpt/excel/tbl_statetotal.xls<http://www.census.gov/popest/states/tables/NST-EST2007-01.xls>

(NST-EST2007-01)

Source: Population Division, U.S. Census Bureau

Release Date: December 27, 2007

Appendix E**The Nuclear Regulatory Commission's Expected New Nuclear Power Plant Applications**

Updated June 4, 2008					
Company *	Design	Date Accepted	Site Under Consideration	State	Existing Op. Plant
Calendar Year (CY) 2007 Applications					
NRG Energy (52-012/013)	ABWR	11/29/2007	South Texas Project (2 units)	TX	Y
NuStart Energy (52-014/015)	AP1000	1/18/2008	Bellefonte (2 units)	AL	N
UNISTAR (52-016)	EPR	1/25/2008	Calvert Cliffs (1 unit)	MD	Y
Dominion (52-017)	ESBWR	1/29/2008	North Anna (1 unit)	VA	Y
Duke (52-018/019)	AP1000	2/25/2008	William Lee Nuclear Station (2 units)	SC	N
2007 TOTAL NUMBER OF APPLICATIONS = 5					
TOTAL NUMBER OF UNITS = 8					
Calendar Year (CY) 2008 Applications					
Progress Energy (52-022/023)	AP1000	4/17/2008	Harris (2 units)	NC	Y
NuStart Energy (52-024)	ESBWR	4/17/2008	Grand Gulf (1 unit)	MS	Y
Southern Nuclear Operating Co. (52-025/026)	AP1000	5/30/2008	Vogtle (2 units)	GA	Y
South Carolina Electric & Gas (743)	AP1000		Summer (2 units)	SC	Y
Progress Energy (756)	AP1000		Levy County (2units)	FL	N
Entergy (745)	ESBWR		River Bend (1 unit)	LA	Y
Exelon (761)	ESBWR		Victoria County (2 units)	TX	N
AmerenUE (750)	EPR		Callaway (1 unit)	MO	Y
PPL Generation (762)	EPR		Bell Bend (1 unit)	PA	Y
UNISTAR (759)	EPR		Nine Mile Point (1 unit)	NY	Y
Luminant Power (754)	USAPWR		Comanche Peak (2 unit)	TX	Y
Detroit Edison (757)	ESBWR		Fermi (1 unit)	MI	Y
Alternate Energy Holdings (765)	EPR		Bruneau (1 unit)	ID	N
2008 TOTAL NUMBER OF APPLICATIONS = 13					
TOTAL NUMBER OF UNITS = 19					
Calendar Year (CY) 2009 Applications					
Florida Power and Light (763)	AP1000		Turkey Point (2 units)	FL	Y
Amarillo Power (752)	EPR		Vicinity of Amarillo (2 units)	TX	UNK
2009 TOTAL NUMBER OF APPLICATIONS = 2					
TOTAL NUMBER OF UNITS = 4					
Calendar Year (CY) 2010 Applications					
Blue Castle Project	TBD		Utah	UT	N
Unannounced	TBD		TBD	TBD	UNK
Unannounced	TBD		TBD	TBD	UNK
2010 TOTAL NUMBER OF APPLICATIONS = 3					
TOTAL NUMBER OF UNITS = 3					
2007-2010 Total Number of Applications = 23					
Total Number of Units = 34					

*Project Numbers/Docket Numbers
 Yellow - Acceptance Review Ongoing

Blue - Accepted/Docketed

<http://www.nrc.gov/reactors/new-licensing/new-licensing-files/expected-new-rx-applications.pdf>

GLOSSARY

Alcohol: A general class of hydrocarbons that contain a hydroxyl group (OH). The term “alcohol” is often used interchangeably with the term “ethanol,” even though there are many types of alcohol.

Alternative fuels: Fuels or energy sources that can replace petroleum-based liquid fuels, particularly for transportation purposes. Examples include biofuels, coal-to-liquid fuels, compressed natural gas, and hybrid (gas/electric) vehicles.

Alternative transportation fuels standard: Governmental requirements that establish goals for ensuring that specified volumes of alternative fuels or technologies are sold or introduced into commerce annually to reduce the dependence on foreign oil and the production of greenhouse gases.

Anaerobic digestion: A biochemical process by which organic matter is decomposed by bacteria in the absence of oxygen, producing methane and other byproducts.

Avoided costs: An investment guideline describing the value of a conservation or generation resource investment by the cost of more expensive resources that a utility would otherwise have to acquire.

Biodiesel: A biofuel produced through transesterification, a process in which organically-derived oils are combined with alcohol (ethanol or methanol) in the presence of a catalyst to form ethyl or methyl ester. The biomass-derived ethyl or methyl esters can be blended with conventional diesel fuel or used as a neat fuel (100 percent biodiesel). Biodiesel can be made from soybean or rapeseed oils, animal fats, waste vegetable oils or microalgae oils.

Biomass: Renewable organic matter such as agricultural crops and residue, wood and wood waste, animal waste, aquatic plants and organic components of municipal and industrial wastes.

Biomass fuel: Liquid, solid or gaseous fuel produced by conversion of biomass.

British thermal unit: (Btu) A unit of heat energy equal to the heat needed to raise the temperature of one pound of water one degree Fahrenheit at one atmosphere pressure (sea level).

Carbon dioxide: A naturally occurring gas, and also a byproduct of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential (GWP) of 1.

Carbon sequestration: The uptake and storage of carbon.

Cellulose: The main carbohydrate in living plants. Cellulose forms the skeletal structure of the plant cell wall.

Cellulosic biofuels: Liquid fuels and blending components produced from cellulose biomass feedstocks, used primarily for transportation (modified from http://www.eia.doe.gov/glossary/glossary_b.htm). Cellulosic feedstocks can be derived from harvested crops, crop residue, or municipal solid waste; cellulosic molecular chains in the biomass are chemically broken with acids or enzymes, making sugar molecules available for bacterial fermentation and ethanol production.

Clean Coal Technology (CCT) program: The CCT program refers to a number of technological advances that make the burning process of coal cleaner by removing pollutants such as sulfur, nitrogen, and fly ash that can contaminate the air and water.

Climate change: Climate change refers to any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change may result from:

- Natural factors, such as changes in the sun's intensity or slow changes in the earth's orbit around the sun.
- Natural processes within the climate system (e.g. changes in ocean circulation).
- Human activities that change the atmosphere's composition (e.g., through burning fossil fuels) and the land surface (e.g., deforestation, reforestation, urbanization, desertification, etc.).

Coal gasification: Coal gasification is the process that changes coal into a gas.

Coal-to-gas: Also known as coal gasification, is the process of converting coal into gas. The basic process involves crushing coal to a powder, which is then heated in the presence of steam and oxygen to produce a gas. The gas is then refined to reduce sulfur and other impurities. The gas can be used as a fuel or processed further and concentrated into chemical or liquid fuel. (http://www.eia.doe.gov/glossary/glossary_c.htm)

Coal-to-liquid: Liquid fuels produced from gasification of coal including dimethyl ether, methanol or synthetic diesel.

Cogeneration: The sequential production of electricity and useful thermal energy from a common fuel source. Rejected heat from industrial processes can be used to power an electric generator (bottoming cycle). Conversely, surplus heat from an electric generating plant can be used for industrial processes, or space and water heating purposes (topping cycle).

Combined cycle: Two or more generation processes in series or in parallel, configured to optimize the energy output of the system.

Combined-cycle system: In a combined-cycle system, gas from heating coal operates a combustion turbine connected to a generator, and the exhaust gases from this turbine heat water that, in turn, operates a steam-powered generator.

Conservation: To reduce or avoid the consumption of a resource (energy) or commodity.

Earth-Coupled Ground Source (Geothermal) Heat Pump: A type of heat pump that uses sealed horizontal or vertical pipes, buried in the ground, as heat exchangers through which a fluid is circulated to transfer heat either from the ground (winter) or into the ground (summer).

Efficiency: The ratio of desired work-type output to the necessary energy input, in any given energy transformation device. An efficient LIGHT bulb for example uses most of the input electrical energy to produce light, not heat. An efficient HEAT bulb uses most of its input to produce heat, not light.

Energy conservation: To reduce or avoid the consumption of a resource or commodity.

Energy crops: Crops grown specifically for their fuel value. These include food crops such as corn and sugarcane and nonfood crops such as poplar trees and switchgrass. Currently, two energy crops are under development in the United States: short-rotation woody crops, which are fast-growing hardwood trees harvested in five to eight years, and herbaceous energy crops, such as perennial grasses, which are harvested annually after taking two to three years to reach full productivity.

Energy efficiency: Energy efficiency refers to products or systems using less energy to do the same or better job than conventional products or systems.

Energy Efficiency Resource Standard (EERS): A market-based mechanism to encourage more efficient generation, transmission, and use of electricity and natural gas by setting electric and/or gas energy savings targets or goals for utilities.

ENERGY STAR: ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy helping businesses and individuals save money and protect the environment through energy efficient products and practices.

Ethanol: Ethyl alcohol produced by fermentation and distillation. An alcohol compound with the chemical formula $\text{CH}_3\text{CH}_2\text{OH}$ formed during sugar fermentation by yeast.

Feedstock: Raw material supplied to a machine or processing plant from which other products can be made. In the case of biofuels, the feedstock is the raw biological material, or biomass, used to produce the biofuels.

Fischer-Tropsch Fuels: Liquid hydrocarbon fuels produced by a process that combines carbon monoxide and hydrogen. The process is used to convert coal, natural gas and low-value refinery products into a high-value diesel substitute fuel.

Flexible-fuel vehicle: A vehicle with a single fuel tank designed to run on varying blends of unleaded gasoline with either ethanol or methanol.

Fluidized-bed combustion (FBC): FBC is a process of burning coal in which the coal is inserted in a bed of particles that are suspended in the air and that react with the coal to heat the furnace more cleanly. In FBC, coal is burned at a slightly lower temperature, which helps prevent some nitrogen oxide gases from forming.

Gasifier: A device for converting solid fuel into gaseous fuel. In biomass systems, the process is also referred to as pyrolytic distillation. See pyrolysis.

Gasification: A chemical or heat process to convert a solid fuel to a gaseous form.

Gasohol: A motor vehicle fuel which is a blend of 90 percent unleaded gasoline with 10 percent ethanol (by volume). This term was used in the late 1970s.

Generator: A machine used for converting rotating mechanical energy to electrical energy.

Geothermal: Pertaining to heat energy extracted from reservoirs in the earth's interior, as in the use of geysers.

Greenhouse effect: The trapping of the sun's radiant energy, so that it cannot be reradiated back into space. In cars and buildings the radiant energy is trapped by glass; in the earth's atmosphere the radiant energy is trapped by gases such as chlorofluorocarbons (CFCs) and carbon dioxide.

Greenhouse gases: Gases that trap the heat of the sun in the Earth's atmosphere, producing the greenhouse effect. The two major greenhouse gases are water vapor and carbon dioxide. Other greenhouse gases include methane, ozone, chlorofluorocarbons, and nitrous oxide.

Grid: An electric utilities industries system for distributing power.

Grid connection: Joining a facility that generates electric power to a utility system so that electricity can flow in either direction between the utility system and the facility.

Hybrid Gasoline-Electric Vehicle (HEV): A hybrid vehicle which combines a conventional gasoline propulsion system with a rechargeable energy storage system to achieve better fuel economy than a conventional vehicle.

Hybrid vehicle: Usually a hybrid electric vehicle (EV), a vehicle that employs a combustion engine system together with an electric propulsion system. Hybrid technologies expand the usable range of EVs beyond what an all-electric-vehicle can achieve with batteries only.

Integrated Resource Planning (IRP): A plan developed by an electric power provider, sometimes as required by a public regulatory commission or agency, that defines the short and long term capacity additions (supply side) and demand side management programs that it will undertake to meet projected energy demands.

Investment tax credit: A specified percentage of the dollar amount of certain new investments that a company can deduct as a credit against its income tax bill.

Investor-owned utility: (IOU) A private power company owned by and responsible to its shareholders.

Kilowatt: (kW) A measure of electrical power equal to 1,000 Watts. $1 \text{ kW} = 3,413 \text{ Btu/hr} = 1.341 \text{ horsepower}$.

Kilowatt hour: (kWh) A measure of energy equivalent to the expenditure of one kilowatt for one hour. For example, 1 kWh will light a 100-watt light bulb for 10 hours. $1 \text{ kWh} = 3,413 \text{ Btu}$.

Landfill gas: Gas that is generated by decomposition of organic material at landfill disposal sites. Landfill gas is approximately 50 percent methane.

Life-cycle costing: A method of comparing costs of equipment or buildings based on original costs plus all operating and maintenance costs over the useful life of the equipment. Future costs are discounted.

Load factor: Load factor is the ratio of average demand to maximum demand or to capacity.

Megawatt: (MW) The electrical unit of power that equals one million Watts (1,000 kW).

Megawatt Hour (MWh): One-thousand kilowatt-hours.

Methane: An odorless, colorless, flammable gas with the formula CH_4 that is the primary constituent of natural gas.

Mil: One-tenth of one cent \$0.001.

Nuclear Regulatory Commission (NRC): An independent federal agency that ensures that strict standards of public health and safety, environmental quality and national security are adhered to by individuals and organizations possessing and using radioactive materials. The NRC is the agency that is mandated with licensing and regulating nuclear power plants in the United States. It was formally established in 1975 after its predecessor, the Atomic Energy Commission, was abolished.

Peak load or Peak demand: The highest electrical demand within a particular period of time. Daily electric peaks on weekdays occur in late afternoon and early evening. Annual peaks occur on hot summer days.

Peak Load Power Plant: A power generating station that is normally used to produce extra electricity during peak load times.

Peaking unit: A power generator used by a utility to produce extra electricity during peak load times.

Plug-In Hybrid Electric Vehicle (PHEV): A hybrid electric vehicle (HEV) which combines a conventional propulsion system with a rechargeable energy storage system that can be recharged by connecting a plug to an electric power source.

Photovoltaic: A system that converts direct sunlight to electricity using semi-conductor materials.

Public Benefit Fund (PBF): Funds collected either through a small charge on the bill of every customer or through specified contributions from electric and/or natural gas utilities that can be used to support renewable energy, energy efficiency, low-income customer programs, or energy R&D programs.

Pyrolysis: The thermal decomposition of biomass at high temperatures (greater than 400 degrees Fahrenheit, or 200 degrees Celsius) in the absence of air. Also called destructive distillation. The end product of pyrolysis is a mixture of solids (char), liquids (oxygenated oils), and gases (methane, carbon monoxide, and carbon dioxide) with proportions determined by operating temperature, pressure, oxygen content, and other conditions.

Quad: One quadrillion Btu (10¹⁵ Btu). An energy equivalent to approximately 172 million barrels of oil.

Renewable and Efficiency Portfolio Standard (REPS): A mandate or goal requiring that a certain percentage of overall energy demand be derived from a combination of energy efficiency, renewable energy and biofuels.

Renewable fuels: Fuels produced from renewable resources, such as biofuels (e.g. vegetable oil used as fuel, ethanol, or biodiesel). This is in contrast to non-renewable fuels such as natural gas, LPG (propane) and other fossil fuels.

Renewable fuels standard: Governmental requirements that establish goals for ensuring that applicable volumes of renewable fuels are sold or introduced into commerce annually. The Energy Independence and Security Act of 2007 (H.R. 6), for example, applies to refiners, blenders and importers and sets forth a phase-in for renewable fuel production volumes beginning with 9 billion gallons in 2008 and ending at 36 billion gallons in 2022.

Renewable Portfolio Standard (RPS): A mandate or goal requiring that a certain percentage of electricity come from renewable sources of energy (e.g. solar, wind, hydro, etc.).

Smart Grid: An electricity transmission and distribution network or “grid” that uses robust two-way communications, distributed computers, and advanced sensors and switches to significantly improve the efficiency, reliability and safety of power delivery and use.

Sustainable: An ecosystem condition in which biodiversity, renewability, and resource productivity are maintained over time.

Syngas: A synthesis gas produced through gasification of biomass. Syngas is similar to natural gas and can be cleaned and conditioned to form a feedstock for production of methanol.

Tariff: A document, approved by the responsible regulatory agency, listing the terms and conditions, including a schedule of prices, under which utility services will be provided.

Transportation Demand Management (TDM): The application of strategies and policies to reduce automobile and truck transport travel demand, or to redistribute this demand in space or in time.

Watt: The common base unit of power in the metric system. One watt equals one joule per second. It is the power developed in a circuit by a current of one ampere flowing through a potential difference of one volt. One Watt = 3.413 Btu/hr.

Wheeling: The process of transferring electrical energy between buyer and seller by way of an intermediate utility or utilities.

<http://www.teachcoal.org/glossary.html>

<http://www.energy.ca.gov/glossary/glossary-xyz.html>

<http://www.oregon.gov/ENERGY/RENEW/glossary.shtml>

<http://www.epa.gov/solar/energy-and-you/glossary.html>

ENERGY TERMS

The basic unit of heat energy is the **British Thermal Unit**, Btu, the amount of heat necessary to raise a pound of water a degree Fahrenheit.

Mcf - Thousand Cubic Feet: One thousand cubic feet. One mcf equals the heating value of 1,000,000 Btu (mmbtu).

Electric power is measured in **watts**, where a watt = 3.412 Btu.

Electric energy is measured in **watt hours**. It is also expressed in kilowatt hours (kWh) = a thousand watt hours, megawatt hours (MWh) = a million watt hours, gigawatt hours (GWh) = a billion watt hours, and terrawatt hours (TWh) = a trillion watt hours.

The table below expresses some relationships between forms of energy:

Fuel	Unit	Btu/Unit	Cost/ Unit	Cost/MBtu
Coal	Ton	28,000,000	\$105	\$ 3.75
Crude Oil	Barrel	6,300,000	\$120	\$ 19.05
Heating Oil	Gallon	140,000	\$3.00	\$ 21.43
Propane	Gallon	92,000	\$2.50	\$ 27.17
Gasoline	Gallon	125,000	\$3.60	\$ 28.80
Natural Gas	Mcf	1,000,000	\$10.50	\$ 10.50
Electricity	kWh	3,412	\$0.07	\$ 20.52

ENVIRONMENTAL TERMS

A short ton is defined as 2000 pounds; a metric ton is 1000 kilograms = 2204 pounds.

CO₂, carbon dioxide, is the most predominant greenhouse gas

NO_x, oxides of nitrogen, are produced by the burning of fossil fuels

SO_x, oxides of sulfur, are produced by burning sulfur-bearing fossil fuels

<http://www.coloradoefficiencyguide.com/glossary/default.htm>

ACRONYMS

A

AEO - Annual Energy Outlook, DOE/EIA publication
ANSI - American National Standards Institute
API - American Petroleum Institute
APPA - American Public Power Association
ASHRAE - American Society of Heating Refrigeration & Air Conditioning Engineers
ASME - American Society of Mechanical Engineers

B

BAU - Business as usual
bbl - barrel
BBLs - barrels of oil
BCF - billion cubic feet
Bcfd - billion cubic feet per day
BTL - Biomass-to-liquid
Btu - British thermal unit

C

CAA - U.S. Clean Air Act
CAFE - Corporate Average Fuel Economy
CFB - circulating fluidized bed
CFCs - chloro-fluorocarbons
CFM - cubic feet per minute
CNG - Compressed natural gas
CO - carbon monoxide
CO₂ or CO₂ - Carbon dioxide
COL - Combined construction and operating license
CT - combustion turbine
CTG - combustion turbine generator
CTG - Coal-to-gas conversion
CTL - Coal-to-liquid conversion

D

DOE - U.S. Department of Energy
DSM - Demand Side Management

E

EIA - Energy Information Administration, division of U.S. Department of Energy
EOR - Enhanced oil recovery
EPA - U.S. Environmental Protection Agency

F

FERC - Federal Energy Regulatory Commission
FT - Fischer-Tropsch process of converting methane, biomass, or coal to liquid fuels

G

GHG - Greenhouse gas (e.g., CO₂, methane)

gpd - gallons per day

GTL - Gas-to-liquids conversion

GW - gigawatt

GWh - gigawatt-hour

H

HVAC - Heating Ventilation and Air Conditioning

I

IEA - International Energy Agency

IRP - Integrated Resource Planning

IOU - Investor-owned Utility

K

KGS - Kentucky Geological Survey

KRS - Kentucky Revised Statutes

kW (small k, capital W) - kilowatt

kWe - kilowatt, electric

kWh - kilowatt hour

kWp - peak kilowatt

L

LBNL - Lawrence Berkeley National Laboratory

lbs - pounds

LEU - Low enriched uranium

LNG - liquefied natural gas

M

MCF - thousand cubic feet

MW - megawatt (million watts)

MWh - megawatt hour

N

NETL- National Energy Technology Laboratory

NO - nitrogen oxide

NO₂ - nitrogen dioxide

NRC - Nuclear Regulatory Commission

NRDC - Natural Resources Defense Council

NREL - National Renewable Energy Laboratory, a laboratory of the U.S. Department of Energy

NSR - New Source Review

O

OPEC - Organization of Petroleum Exporting Countries

ORNL - Oak Ridge National Laboratory

P

PHEV- Plug-in Hybrid Electric Vehicle

PM - particulate matter

PM10 - particulate matter 10 microns and smaller in diameter

PM2.5 - particulate matter 2.5 microns and smaller in diameter

PV - photovoltaic

Q

Quad - one quadrillion (10^{15}) British thermal units

R

RTO - Regional Transmission Organization

RTP - real-time pricing

S

SNG - Synthetic Natural Gas

SO₂ - sulfur dioxide

SO₄ - sulfates

SO_x - sulfur oxides

T

TBtu - trillion Btu

TCF - trillion cubic feet

TCF - Trillion cubic feet (dry natural gas)

U

U.S. DOE - United States Department of Energy

USCOE - U.S. Corps of Engineers

USGS - United States Geological Survey

V

VOC - volatile organic compounds

W

W - Watt

<http://www.energy.ca.gov/glossary/acronyms.html>